LOCAL DROUGHT MANAGEMENT PLANNING GUIDE FOR PUBLIC WATER SUPPLIERS

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Office of Water Management
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I. INTRODUCTION

A. BACKGROUND

Many water utilities in Tennessee could face significant operational and supply-related problems during droughts or other emergencies. These problems are caused by the combined effects of less water available from the source, increased demands for water from customers, and stress on system equipment. Even water quality degradation is a potential problem in a drought.

Industry is expanding in many areas of Tennessee, and Tennessee's population is continuing to increase. As water supply conditions change and demand increases, temporary shortages in water supply are likely. An emergency or an extended drought can severely diminish or limit the use of stream, reservoir, and groundwater supplies. In many emergencies, the final phases of a drought management plan can be used to deal with power outages, hazardous materials spills, line breaks or other emergencies having a severe impact. An emergency operations plan (or EOP) is required by the Division of Water Supply under its Rules.

Water utilities that have experienced serious and costly water shortages stemming from changing conditions in water supply and demand should include drought management in their emergency management plan. In addition, public water systems which may be impacted by a drought were identified in the study, "Drought-Related Impacts on Municipal and Major Self-Supplied Industrial Water Withdrawals in Tennessee" (Parts A and B) by Alexander, Keck, Conn and Wentz, 1984.

A local drought management plan outlines the actions a public water supplier will take in order to limit adverse effects during a drought. The possible issues, rationale and responses which should be considered in developing a local drought management plan are the subject of this Guide.

B. PURPOSE

This Guide has been prepared to help public water supply managers (1) assess their situation, (2) develop a drought management plan, (3) identify and monitor drought stages, and (4) effectively manage system supply and demand during a drought. It focuses on developing a drought management plan for public water supplies. This Guide should serve as a basic reference document to the "Summary." The materials in this Guide are drawn heavily from the sources listed on page 99, "Literature Cited". Another document, "Guidelines for Emergency Operations Planning for Community Water Systems," (to be printed) provides details on developing emergency operations procedures (EOPs), which are needed to meet the State's minimal emergency planning requirements.

This Guide does not address detailed planning for developing water supplies nor other responses requiring a considerable expenditure of time or money. Such planning and system expansion or renovation should be handled as a part of normal operations and maintenance. Where a system or source of water fails to meet the most essential demands, that supplier may choose to embark on a program for improving the system's capacity through development of alternative supplies of water, overall demand reduction, leakage control, etc.

Rather than focus on source development, this Guide emphasizes the development of a plan (1) to manage available supplies and uses during a drought and (2) to identify alternative sources which could be used on a short-term, interim basis to alleviate a water shortage. Auxiliary sources which are not already owned take time to acquire and develop. The Guide accepts as given, situations that cannot be altered without considerable money or time. Where a water system finds it cannot tolerate the restrictions that would accompany potential water supply shortages, the plan may indicate to the system its need to develop alternative water supplies and/or reduce overall demand. These considerations, however, do not negate the fact that all users face some risk.

Drought management planning can be invaluable in determining what chances are going to be taken and what consequences exist for water users. Acceptable levels of service must be established for various uses and the available water resources managed accordingly. For example, priorities should be established for essential needs such as hospitals, nursing homes, emergency shelters, decontamination of lines, and firefighting over such uses as lawn watering and street cleaning. This Guide will help water suppliers to establish priorities.

II. OVERVIEW OF GUIDE ELEMENTS

This Guide begins by clarifying the roles of local, state, regional and federal agencies. It identifies possible goals and objectives for plans containing phase responses as well as the need for public participation in their development. It also discusses the need for an accurate and timely assessment of source supplies and distribution capability, potential water quality problems, assessing current and peak demand, and the development of a phased program of balancing the supply and demand of water in an equitable and acceptable manner. Many optional local responses to water shortages are identified, with each having a different set of potential benefits. Finally, the Guide addresses the administrative and enforcement needs of drought management, as well as the need for an ordinance or by-law enabling the system to exercise these management prerogatives, and the need to educate the public concerning plan implementation.

The steps taken by this Guide develop a plan as shown in Figure 1, "Developing a Local Drought Management Plan." Several of the steps detailed in the figure can be undertaken at the same time, i.e., assessing source capacity, identifying potential water quality problems, and estimating current and projected demand. Other steps are better developed in a progressive order, i.e., from identifying goals and objectives to assessing demands and water sources, and establishing water use priorities to adopting an ordinance enabling the system to implement its plan. Suppliers should use Figure 1 in developing a local plan. Public involvement should occur throughout the plan development process.

Figure 2, "Balancing the Water System's Supply and Demand," focuses on the collective purpose of all the steps, i.e., to develop an acceptable plan to balance the system's demand for water with its supply of water at three levels of availability. Figure 2, part A shows a water system in crisis as a result of unmanaged water use. Under wet and normal conditions water demands are met by the system. The capacity of the source and the capacity to treat and deliver water is far from being stressed. Average daily use (demand) is near 80 percent of deliverable capacity. As conditions become dry and the source's capacity begins to decline, water demand increases due to lawn watering, additional bathing and laundering, etc. Water demand may approach the system's deliverable capacity. In a drought a source's capacity may decline to its 3Q20, minimum reservoir level, etc., or even decline below its safe yield. When the water system's deliverable capacity is insufficient to meet total demand, the system will be in crisis and many critical needs will not be met by the system.

Figure 2, part B shows a water system meeting critical needs though supplies are deteriorating and demand is increasing. As drought conditions persist, source capacity declines and/or total water demand continues to increase. The system begins a program for managing water use in keeping with its deliverable supply. The system has defined three levels of service in response to increasingly severe drought conditions. These phases are called "Conservation," "Restrictions," and "Emergency." Under its "Conservation" phase, water demand is designed to be reduced by 15-20 percent. Water service to meet First, Second and Third Class Essential uses are maintained. Under the "Restrictions" phase water demand is reduced a total of 30-40 percent.

Figure 1
Developing a Local Drought Management Plan

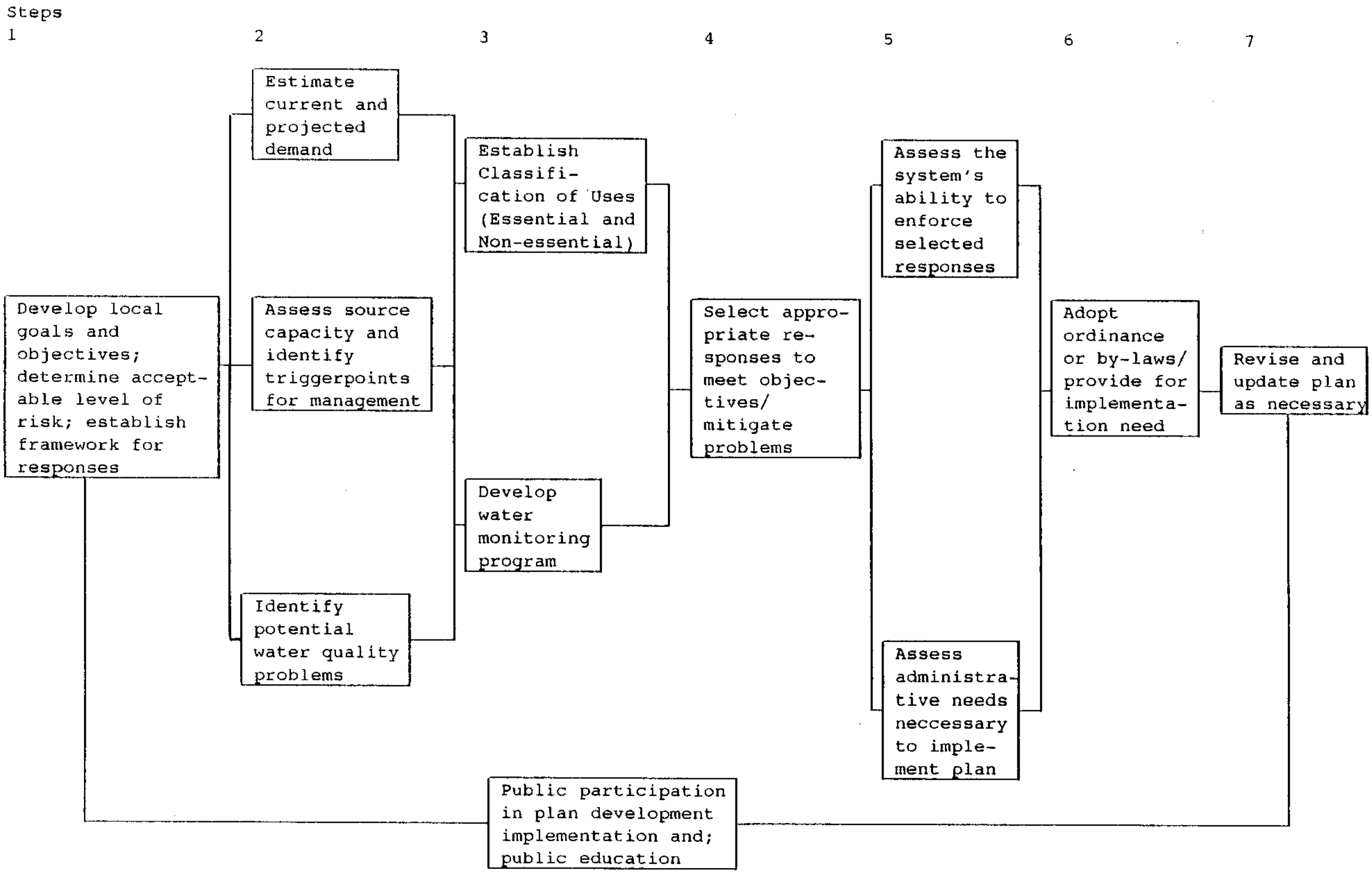
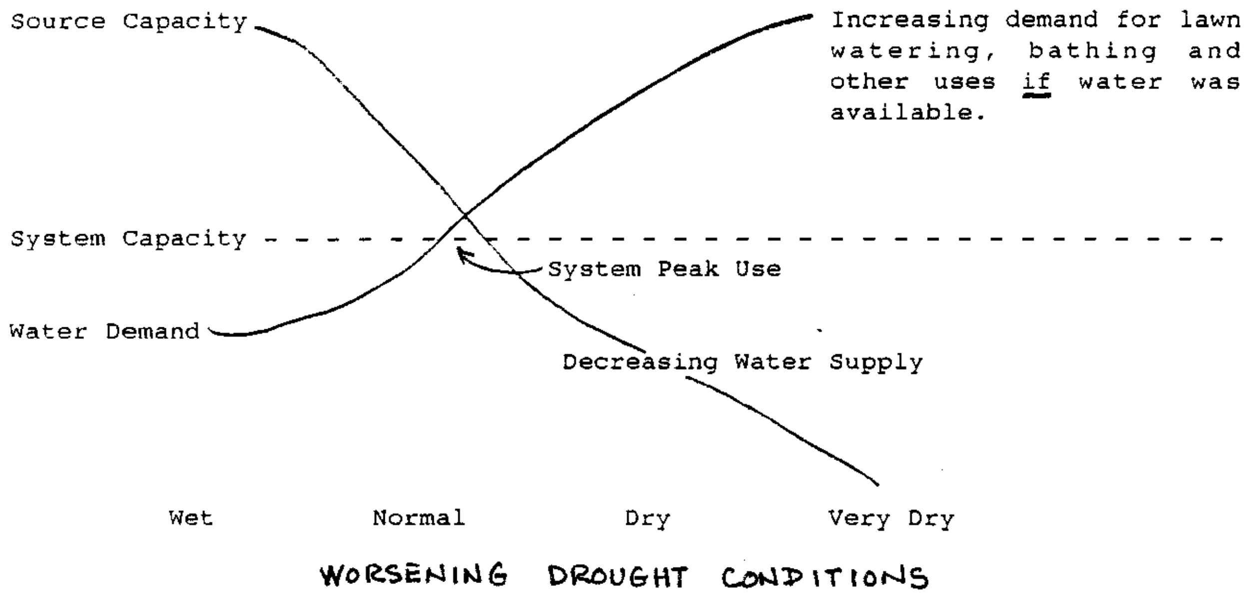


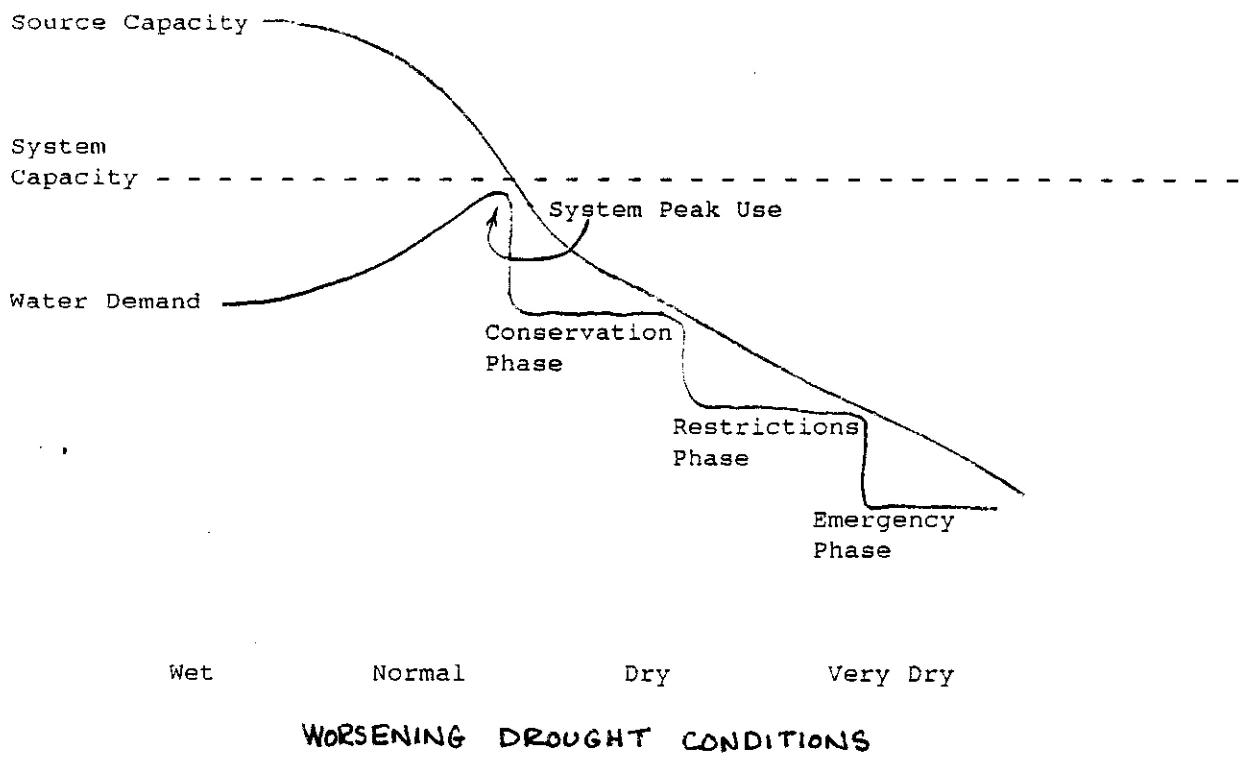
Figure 2

Balancing the Water System's Supply and Demand

A. Unmanaged Water Use



B. Managed Water Use



Non-essential, Third Class and possibly Second Class Essential uses should be curtailed. Under the "Emergency" phase water demand is reduced a total of 60 percent or more. Throughout the three phases water demand is balanced with the system's available water supply. Water use does not exceed the system's deliverable capacity.

As an aid to developing a drought management plan, this Guide recommends that the three levels of service defined above be incorporated in the system's drought management plan. Other, additional phases may be developed by the water supplier as appropriate. In particular, water suppliers may want to develop additional management phases which would apply to various emergency situations.

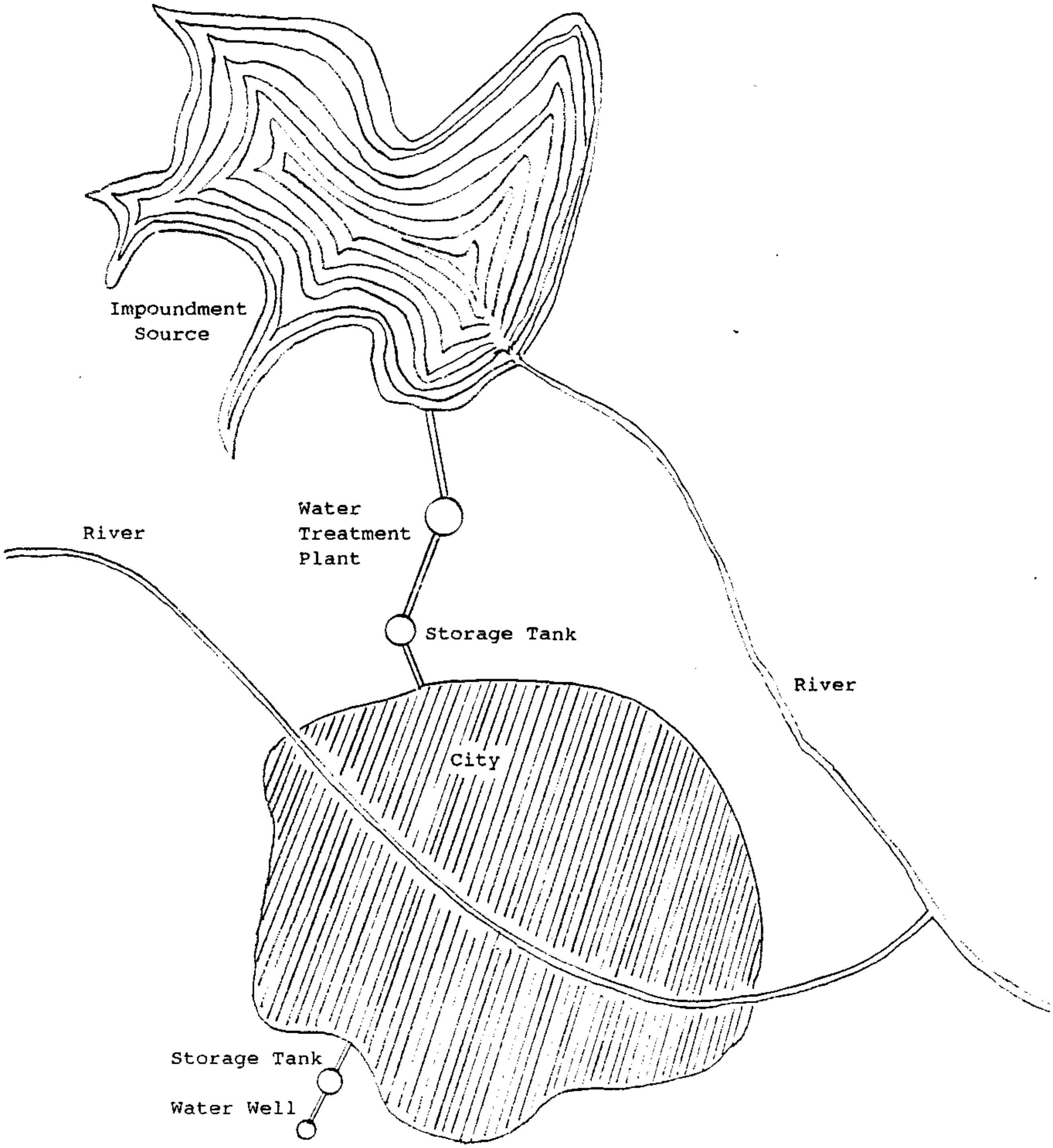
All suppliers need to plan for all three drought management phases and assign an appropriate triggerpoint to signal the implementation of each phase. Reductions in supply are possible for all suppliers, even those who consider themselves to be "drought-proof." Instead of a drought, supply reductions may result from a toxic spill preventing withdrawal of water from a reservoir or river, or because of a major fire, linebreak, power outage, treatment plant or storage problem. A supplier's drought management plan should provide an excellent basis for continued emergency management planning. In addition to drought, a local or county comprehensive emergency management plan will consider the effects of all potential emergencies on many services and for each of their components, recognizing that each disaster or emergency, e.g., earthquake, snowstorm, etc., has its own characteristics. Identifying the effects produced by particular disasters should help water system managers better anticipate their management responses, although many disasters will have the same result. However, a system with a resultant water supply loss must consider the cause in light of its overall extent, specific impacts on other services and need for coordination with other agencies. The local emergency planning committee (or county emergency management agency) should develop plans and procedures for handling multiple service needs.

Some public water suppliers may have several treatment plants, reservoirs, or sources of supply. The service areas for each of these may need to be considered independently when evaluating delivering capacity, identifying priorities, potential reductions in usage, health and safety considerations, and management phase. Figure 3, "Municipal Water System With Two Sources," shows a system with major two components. A supplier, like that shown in Figure 3, can subdivide its plan measures dealing with the critical components, e.g., water treatment facilities, distribution system, transmission system, trained personnel, or sources. Important components of each section of the system should be identified. Although components can be planned for subdivided sections separately, the planned measures can be undertaken systemwide as circumstances dictate. Plans should provide a clear breakdown of each subsystem and the emergency operations procedures (EOPs) that should be used under each phase.

A drought management plan should be developed in response to clearly defined objectives. The better these broad objectives are defined by a public water supplier, the greater the possibility that planned responses will be appropriate for the circumstances. Systems may include additional phases and detail beyond what is described in this Guide.

Figure 3

Municipal Water System with Two Sources



Because a water supplier serving almost exclusively domestic users is so nearly uniform, its foremost objective may be to provide adequate supplies to its elderly and handicapped residents. The system may use a pricing structure which prices excess use above an established "lifeline" minimum at a significantly higher rate. Another system with a vulnerable source may be more concerned about prolonged industrial layoffs as a result of drought. That community may want to keep as many of its labor intensive businesses and industrial users operating as long as possible. Identifying the system's objectives helps develop a phased management plan to balance the supply and demand of water.

A water supplier can begin identifying its possible health, economic, and social objectives, system components, opportunities for reducing use, etc., by completing Appendix A, "Drought Management Planning Inventory For Public Supply Systems," in this Guide. For the sake of simplicity and consistency concerning objectives, this Guide will deal primarily with the minimal three phases suggested by the Office of Water Management.

III. AGENCY ROLES AND RESPONSIBILITIES

The "Interim State Drought Management Plan" is the Department of Health and Environment's interim plan for the management of water under drought conditions. The Plan was developed based on several related mandates in Tennessee statutes. These are the Water Resources Division Act of 1957, which authorizes the Department of Health and Environment to provide general direction in all matters pertaining to the conservation, protection, and development of Tennessee's waters, including development and implementation of a basic, long-range water resources policy; the Tennessee Safe Drinking Water Act of 1983, which requires development of a plan for the provision of safe drinking water under emergency circumstances; and the Tennessee Water Quality Control Act of 1977 as amended, under which the Water Quality Control Board has adopted a plan for the protection and preservation of the state's waters. The Interim State Drought Management Plan also serves in part as the emergency water management plan authorized under the Tennessee Safe Drinking Water Act [redacted], (Keck, 1987).

The Rules of the Tennessee Department of Health and Environment, Chapter 1200-5-.17(7), require that "...all community water systems shall prepare an emergency operations plan in order to safeguard the water supply and to alert the public of unsafe drinking water in the event of natural or man-made disasters." The Interim State Drought Management Plan outlines in broad terms the procedures and roles to be taken by water users and managers during a drought.

In the State's plan, the Commissioner of the Department of Health and Environment advises public water suppliers and other local users to develop their own emergency response plans. The responsibility to develop and implement a local drought management plan is local. Local plans insure that local circumstances are recognized and that critical local needs are met. The plan should detail "phased" responses to address increasingly severe drought conditions. Recommended phases include a "Conservation" phase, a "Restrictions" phase, and an "Emergency" phase (Keck, 1987).

Furthermore, the Commissioner recommends that every plan consider source capacity, hydraulic limitations of the facility, how water is used, and possible water quality problems due to low flow. Specific actions included in the plan under each phase should be based on local circumstances and needs, and the acceptability of remedies to the public. Each user or system has a unique set of demands that must be considered in context.

Because all users are potentially subject to decreases in water availability due either to a source or facility limitation, development of an emergency management plan is essential. Source and facilities planning should make sense and be cost effective. This planning Guide is directed toward drought management. However, many of the principles that are utilized in managing water supplies in a drought also apply to other emergency situations where the water supply to the public is cut back or cut off. Storage tank failures, sudden contamination of supply, treatment plant failures, and pump failures are water supply problems that should be addressed and made part of the plan's emergency operations procedures (refer to Chapter XI, "Planning for Implementation" and the Division of Water Supply's "Guidelines for Emergency Operations Planning for Community Water Systems.")

Water suppliers will need to distinguish among emergencies the roles and assignments that are appropriate for other agencies and individuals. (Chapter VIII, "Identifying Management Triggerpoints," characterizes the various degrees of drought as well as types of emergencies.)

Problems and needs that are regional or statewide should be addressed by agencies having a state or regional water management responsibility. The Interim State Drought Management Plan also recognizes that some problems may be beyond the state's authority or ability to manage. Figure 4, "Drought Responses," identifies not only the scope of this Guide but also the roles of other agencies under various drought scenarios. Because circumstances and needs differ locally, State and Federal roles primarily consist of data collection, information dissemination, technical assistance, and regulatory oversight (Keck, 1987).

Where conflicts over water rights and water quality problems emerge or local situations become emergency situations, the Tennessee Office of Water Management, the Tennessee Emergency Management Agency, and the Governor can enter the situation. Once a situation is declared an emergency, special actions can be taken under the Commissioner's or Governor's emergency powers authority. Conflicts involving water rights will be handled on an emergency, case-by-case basis (Keck, 1987).

Within this framework, public water suppliers are afforded considerable flexibility to meet the needs of their situation. The management strategies developed by local suppliers are extremely important in lessening impacts and delaying or averting further water use restrictions.

Figure 4

Drought Responses

Condition and Management Phase*	State and Federal Actions	Local Actions		
		Public Water Suppliers	Industrial	Agricultural, Self-Supplied, Environmental
Normal Conditions Water supply is adequate; water quality is acceptable under normal management	.Develop precipitation, streamflow, ground water, and water quality monitoring programs .Conduct state and regional water studies and coordinate recommended actions .Assist public water suppliers and local government in developing Emergency Water Management plans .Establish public education program	.Develop local drought management plan .Develop additional storage and treatment facilities; evaluate distribution system .Adopt standby rates, other necessary ordinances and codes, and establish mutual aid agreements, interconnections, conservation education, etc.	.Develop local drought management plan .Develop additional wastewater storage .Develop alternative water supplies, water storage and conservation measures .Purchase standby equipment and install permanent equipment as necessary for recycling	.Develop local drought management plan .Evaluate need for irrigation .Enlarge pond, purchase tanks, drill wells, install conservation devices and livestock watering tanks .Evaluate agricultural water use and find where conservation could be used, including use of "drip" irrigation .Evaluate domestic water use and install water-saving devices, etc. to reduce stress on supply source
Drought Alert Lower than normal precipitation, declining streamflows, reservoir levels, and groundwater levels; greater than normal demand	.State issues Drought Alert to media and notifies targeted water users (Alerts may be regional or local) .Intensify selected monitoring activities .State initiates an awareness program	.Monitor water sources and daily water use for specific purposes and anticipate user demand .Monitor potential conflicts and problems	.Monitor water sources and daily water use for specific purposes and anticipate demand .Monitor water quality	.Monitor water sources and daily water use for specific purposes and anticipate demand

Figure 4

Drought Responses (continued)

Condition and Management Phase*	State and Federal Actions	Local Actions: Public Water Suppliers	Local Actions: Industrial	Local Actions: Agricultural, Self-Supplied, Environmental
Conservation Phase Water supplies/ water quality deteriorating or conflicts among users	.Disseminate water supply and water quality data .Monitor systems and users having past problems and monitor plan implementation .Coordinate state and federal supply and water quality actions .Respond to local and individual appeals for assistance ."Post" streams where water quality standards are not met .Commissioner issues orders to water suppliers and/or dischargers	.Implement "conservation" phase at plan triggering point. Potential conservation measures include curtailment of outside uses, education, and pricing .If conservation goal is not obtained, implement restrictions .Notify OWM of sources conflicts	.Institute recycling, cutback production, store wastewater, alter production schedule per industrial water management plan during a drought .If goals are not met, implement additional measures .Notify OWM of source conflicts	.If assessed source is capable, irrigate crops .Provide tanks, maintain streamflows, etc., to meet supply needs of livestock, fish, and aquatic life .Continue conservation of domestic supplies .Notify OWM of source conflicts
Restrictions Phase Continued decline in water supply and/or water quality	.Same responses as in Conservation Phase	.Implement "restrictions" phase at plan triggering point. Restrictions could include banning of some outdoor water uses, per capita quotas, cut-backs to non-residential users .Notify OWM of source conflicts	.Institute additional cut-backs in production, storage of wastewater, or changes in production schedule, etc., per industrial water management plan .Notify OWM of source conflicts	.Same responses as in Conservation Phase

Figure 4

Drought Responses (continued)

Condition and Management Phase*	State and Federal Actions	Local Actions		
		Public Water Suppliers	Industrial	Agricultural, Self-Supplied, Environmental
Emergency Phase Severe water supply or water quality problems due to very limited resource availability	.Governor responds to critical situations by declaring an emergency .TEMA takes action .OWM mediates in conflicts of source utilization under emergency powers	.Notify TEMA and request emergency declaration .Provide bottled water and sanitation supplies to users .Make hospitals, fire-fighting, etc., priority .Initiate hauling of water .Comply with Commissioner's Orders	.Request emergency declaration of Governor .Comply with Commissioner's Orders .Request assistance from local government .Implement hauling water for sanitation, domestic uses	.Local government assistance in obtaintaining water for domestic purposes, and in supporting livestock .Implement hauling water, etc.

*Each phase would be marked by some event or percent of water supply deficit (triggerpoint) as defined locally.

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IV. GOALS AND OBJECTIVES

In order to effectively accomodate the public interest, efforts should be made to identify practical water-related goals and objectives needed during times of water shortage.

The goals of a local public water supplier's drought and emergency management plan may include:

1) equitable distribution of available water supplies among all water users during times of drought, or other water shortage, consistent with goals of minimizing adverse economic, social, environmental, and health related impacts;
2) a basis for management decisions related to the use of water under varying water shortage conditions; and
3) advance knowledge of actions that will be taken during times of water shortage to facilitate implementation in a timely and orderly manner and promote greater security among water users. A plan ensures that adequate notice has been given to customers prior to any restriction or termination of service.

More specific goals relating to levels of service under each management phase may be included in a drought management plan depending on the circumstances of the system.

Good management must know the dependable capacity of a water source, the capability of equipment to deliver water, and understand the demand. Assessing risk for water shortage is uncertain because forecasting is imperfect. Some risk will always be present, and the tolerance of risk among users will vary. Where users have a low tolerance for risk, severe drought conditions make sure water availability possible only after considerable source and facility development.

The dependable capacity of a supply source is simply the maintained output of a source during a severe and extended drought. Where a system's capacity to treat and deliver water determines the deliverable capacity of a system, monitoring the system's source may not be necessary. Managers must then monitor water use demand. If water users have a low tolerance for water use restrictions, the system may also need to undertake a long-term investment strategy to reduce the risk of short supplies.

A long-term water development plan to meet growing water needs over an extended period should be part of the supplier's normal planning for growth. Such strategies may involve cooperative agreements or the regionalization of systems to develop a source which is otherwise economically unattainable. Another long-term strategy is to reduce overall demand through non-voluntary water conservation. These long-term plans reduce risk and improve the margin of safety.

Recommended criteria (several exceeding State minimum standards) for evaluating a system's resistance to water shortage include:

1) Pump-tested wells and/or 3Q20 flows sufficient to meet the capacity of the system;
2) impoundments totalling 90-days or more storage of raw water;

3) minimum 3-day or longer storage capacity for finished water;
4) less than 10 to 12 percent losses of treated water through leaks;
5) treatment plant capacity that exceeds previous 12 month average daily use by 30 or more percent; and
6) a minimum water pressure of 60 psi (pounds per square inch of pressure) in all distribution lines.

Water systems that do not meet most of these criteria might have difficulty satisfying water demands during a peak use period exceeding 4 to 6 weeks. A system that meets or exceeds these criteria reduces the risk of shortage to its customers. Developing facilities and sources that meet these criteria depends on whether more frequent water shortages are acceptable to users given the developmental costs.

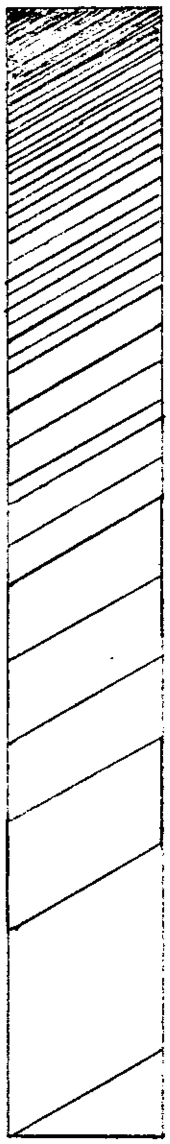
Risk involves both the probability of a water shortage and its subsequent impacts. Risk factors include the source availability of water; the extent of population at risk; the degree to which the system serves critical, non-deferrable needs; the diversity of source types and/or number of sources utilized by the system; capacity and condition of system infrastructure; the diversity of uses (industrial, commercial, institutional, residential, etc.); the vulnerability of sources to contamination, etc. A local drought management plan should contain all the information requested in Appendix A, "Drought Management Planning Inventory for Public Water Supply Systems." It should also contain maps showing the layout of the water system in relation to important area features, such as power facilities, highways, railroads, streams, chemical plants, aviation routes, and other landmarks. Systems serving many users with little tolerance for risk likewise cannot tolerate a great deal of risk. Figure 5, "Factors in Evaluating Risk," provides a checklist for evaluating a system and identifying possible goals and objectives.

Facilities with large sources and those which are willing and/or able to accept extensive restrictions and cut backs over long periods need a drought management plan to be orderly and equitable in the event of a shortage. A really good management plan will deal with unexpected emergency shortages as well as drought. It will address shortages whatever the cause. A good plan reduces the system's vulnerability. It could suggest additional plant security or acquiring auxiliary equipment, as well as temporary conservation actions that focus on reducing water demand during the shortage, and actions to increase supplies. Plans for restrictions and obtaining other sources of water are most essential, in effectively dealing with supply shortages. Controlling risk with a short-term water management plan requires knowing what your priorities or service goals are under various degrees of diminished supply.

Figure 5

Factors in Evaluating Risk

High Risk



Low Risk

Limited or no storage for finished water
Unknown source capacity of streams and/or wells
3Q20 flow less than average daily demand
No interruptable service contracts
History of many linebreaks and shortages
Single source of water, no interconnections with other systems
Poor infrastructure capacity or condition (leakage exceeds 15 percent)
Large number of users with critical non-deferrable needs (concerning public health and safety)
Vulnerable to hazardous materials spills or other contamination
No drought and emergency management plan
No emergency power source(s) supporting system components (booster stations, well pumps, etc.)
Minimum water pressure less than 60 psi in areas of the system
No facility security
No emergency personnel

Adopted drought and emergency management plan and ordinance
Diversity of water user groups
3Q20 which exceeds treatment capacity
History of linebreaks and shortages
Diversity of sources and/or source types
Average daily use 70 percent or less of treatment capacity
10 percent or less leakage of treated water
3-day or longer storage of finished water
90-day or more storage of raw water
An emergency power source
Secured facility
Low vulnerability to hazardous materials spills or other contamination
Minimum water pressure of 60 psi in all distribution lines
Trained emergency personnel available

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V. PUBLIC INVOLVEMENT IN PLAN DEVELOPMENT

While the responsibility of developing a local drought management plan rests with local water officials (or their staff assigned to develop a management plan), the creation of an advisory group to be involved in developing a drought management plan may be critical to the plan's usefulness. Who should be involved depends on the institutional characteristics of the system, whether it is a municipal department, a utility district or an investor-owned system.

If the system serves a small community, an advisory group or task force can provide meaningful input and feedback needed to analyze and shape a plan. If the system serves a large urban area, a formalized board may be needed which presents proposals to the public for ratification. The advisory group should consult interest groups and/or major users with a large stake in water management. When other emergencies are considered, many other groups, and public agencies may have a vital interest in coordinating their actions with the actions of the system. Where alternative responses are identified public meetings and other means of exposure may be planned to allow for public discussion. An advisory group or task force helps insure appropriate and effective community response.

Consider involving representatives from the following (Wood and others, 1986):

County Emergency Management Agency (Civil Defense)
County Health Department Official
Hospital Administrators/Nursing Home Operators
Chamber of Commerce
County Executive or Official
Churches
Mayor(s), City Manager(s) or Other City Official(s)
Fire Chief
Legal Representative
Division of Water Supply, Office of Water Management
Businesses and Industries (which purchase from the system)
Media Representatives (TV, radio and newspapers)
Professional Groups
PTA/School Officials
Water System or District Personnel
Residential Groups

The advisory group can provide some direction to water system officials in gathering information related to sources, demand and system capability. Members might make a list of essential uses and evaluate the amounts of water used by hospitals, jails, and nursing homes. They may suggest which options are more suitable for reducing demand and explore potential auxilary sources of supply, including lakes, quarries, additional wells, etc. They are most valuable in identifying potential exceptions to rules and developing policies and approaches which address special needs (Wood and others, 1986).

The major task of an advisory group is to advise and assist system officials in formulating the plan. Group members should anticipate impacts, identify service areas having a priority, suggest appropriate responses and measures, and promote the plan among their constituents. After the plan has been activated, they should consider the effectiveness of the plan in insuring adequate water supplies (Wood and others, 1986).

The advisory group can provide much needed support where difficult decisions must be made by water system managers. They should represent community perspectives in evaluating conditions and activating or de-activating specific management phases. They can assist in public education, promote adoption of the plan, organize and oversee its implementation. The group may also oversee interagency coordination, and serve an appeals role, for granting variances where circumstances are unique. They should serve as a consensus-building group so that local decisions have general political and community support.

The first role of the advisory group should be to assist development of a drought management plan which can be adopted by the city, commissioners of the district system, or on record with the investor company. An official ordinance authorizing powers necessary for the implementation of the plan, or the adoption of plan itself, may be necessary before the plan can be activated.

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VI. ASSESSING SOURCE CAPACITY

In Tennessee, there are extreme variations in types and character of water sources. The capacity of each source and its contribution to the system is important in understanding potentials for water shortage. Systems with a limited source may expect to impose conservation and restriction measures more frequently than systems with almost limitless source capacity. Consequently, each situation must be analyzed to determine how a local municipality or water utility manager is to respond to a state declaration of "Drought Alert."

Assessing a source's capacity during drought is essential to a management plan. Current supply, especially for wells and streams, should be compared to historical records if available. Records for drought years are especially helpful. Besides the dry period 1985-1987, other years of moderate to severe drought conditions in Tennessee include 1981, 1969-70, 1966, 1959, 1953-54, 1940-42, 1930-31, 1925-26, 1914, 1910, 1904, 1894-96, 1885 and 1877-78.

A. GROUND WATER

"Water wells rely on ground water, which is drawn from underground aquifers. The available supply is measured in **specific capacity.**" Specific capacity of a well can be measured by dividing the volume of water withdrawn (gallons per minute), by the drawdown (the distance the water level falls in a well when the well is pumped) (Wood and others, 1986).

$$\text{Specific Capacity (gpm/ft.)} = \frac{\text{volume withdrawn in gallons per minute (gpm)}}{\text{feet of drawdown}}$$

If there are past records of specific capacity, or if the original specific capacity of a well is known, they can be used to determine the decrease of available water in the well. Current specific capacity can also be expressed as a percent of specific capacity under normal conditions by dividing the specific capacity under present hydrologic conditions by the specific capacity under normal conditions and multiplying by 100 (Wood and others, 1986).

$$\text{Percent of Original Capacity} = \frac{\text{specific capacity (present conditions)} \times 100}{\text{specific capacity (normal conditions)}}$$

If specific capacity drops below 80 percent of normal specific capacity, a hydrologist should be consulted. There may be some cases if specific capacity under "normal" conditions is not known. In those cases if the specific capacity decreases 6 percent or more over a two month period, a hydrologist should be consulted (Wood and others, 1986).

Where historic records are not available, data collection should be initiated. If a facility has a maintenance contract for its wells, the maintenance company should have calculated the change in specific capacity. Many large well drilling companies have resident hydrologists who can analyze well data (Wood and others, 1986).

All public suppliers should routinely measure static water level (the water level when not pumping) and drawdown of their wells. These measurements should be made on a daily basis during supply shortages and weekly during normal conditions. Static ground water levels tend to fall during dry periods and rise during wet periods. Drawdown and static water levels can be plotted on graphs like those in Figure 6, "Static Water Level" and Figure 7, "Water Drawdown Level," (Wood and others, 1986). When static water levels or drawdown approach the well screen or pump or when other problems are encountered, a hydrologist should be consulted. In West Tennessee, a declining static water level may provide a good basis on which to base water management. Wells which cannot be measured for drawdown or static water level should be modified so that measurements can be made (Wood and others, 1986).

"Ground water aquifers are usually an excellent source of water because they have high storage capacity, constant temperature, and very little evaporation. However, they can be overdrawn" (Wood and others, 1986). If further information is needed on ground water resources, contact the Office of Water Management, Division of Ground Water Protection, 615/741-0690.

Measuring Water Levels and Depths

Daily or weekly measurements of the depth of static water level (the level when no pumping is occurring) indicate trends in the amount of ground water available for use. These readings should be taken when the pump is off and the water level has stabilized. Static water level should be measured just before the well enters a pumping cycle" (Wood and others, 1986).

Another useful well measurement is drawdown level (the reduction in water level while the pump is running). Drawdown is measured after the pump has been operating long enough for the water level to stabilize at a constant or nearly constant level. Comparison of drawdown and static water level measurements over time allows an operator to recognize drops in well efficiency caused by incrustation of screens or decreases in aquifer water levels (Wood and others, 1986).

Methods for measuring depth include:

Chalked Tape Method (see Figure 8, "Chalked Tape Method for Well Water Level Measurements")

A steel or fiberglass surveying tape long enough to reach the water and carpenter's chalkline chalk are needed. The tape should have a weight on the end to help prevent it from sticking to the side of the casing. Bolts securely fastened to the end of the tape can be used. The first ten feet of the tape should be chalked. The chalk on the tape is used to establish a water mark on the tape, when it is completely lowered (Wood and others, 1986).

The tape should be lowered in short quick drops (one foot at a time). A splash will be made by the weight when it hits the water. The tape should be lowered until it reaches the bottom. The tape should then be pulled out, the number at the water mark noted and subtracted from the previous number. The result is the depth to water. The chalked tape method cannot be used in wells with cascading water (Wood and others, 1986).

Electric Tape Method (see Figure 9, "Electric Tape Method For Well Water Land Measurements")

STATIC WATER LEVEL

Well No.__________

Month______________

19____

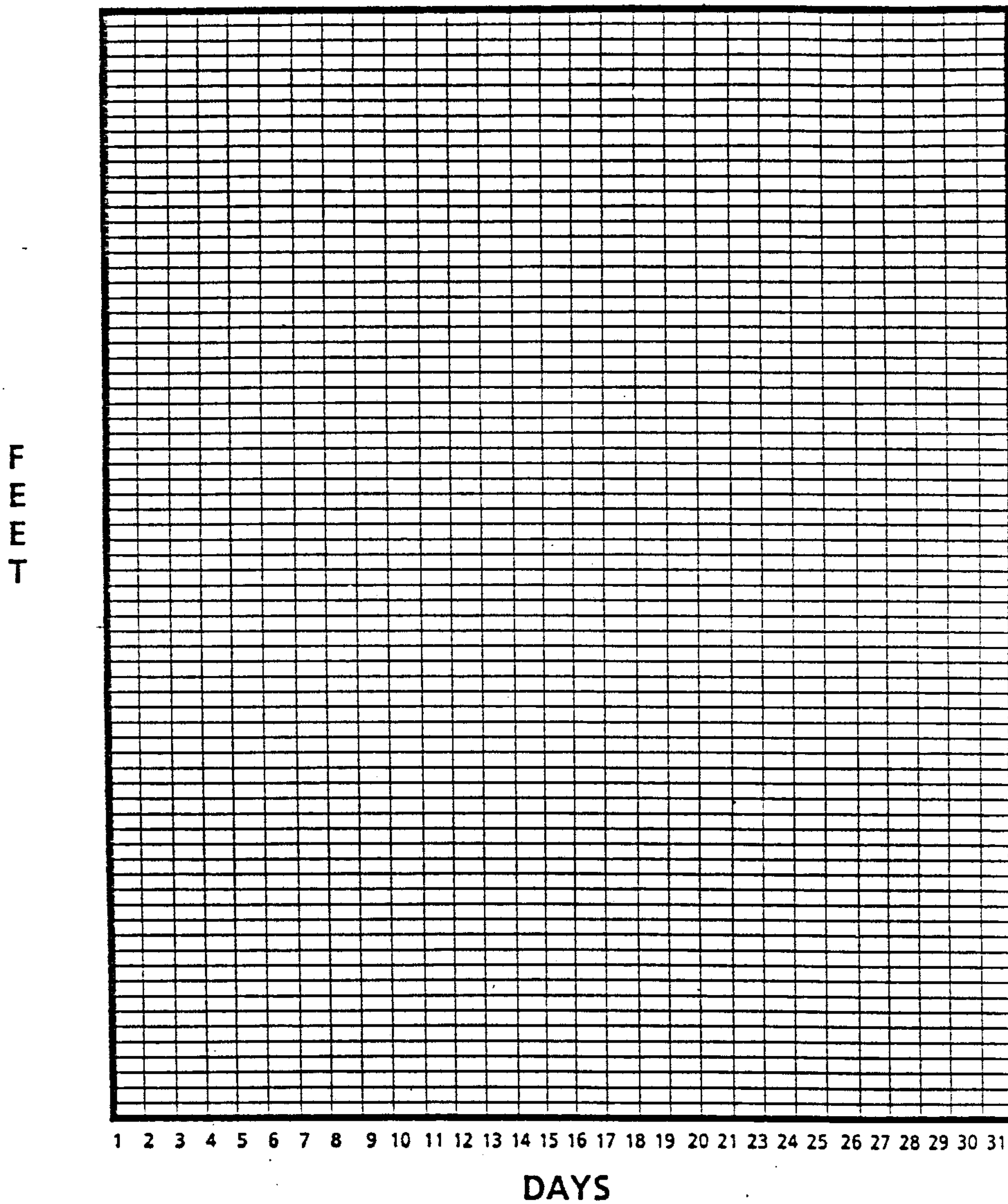
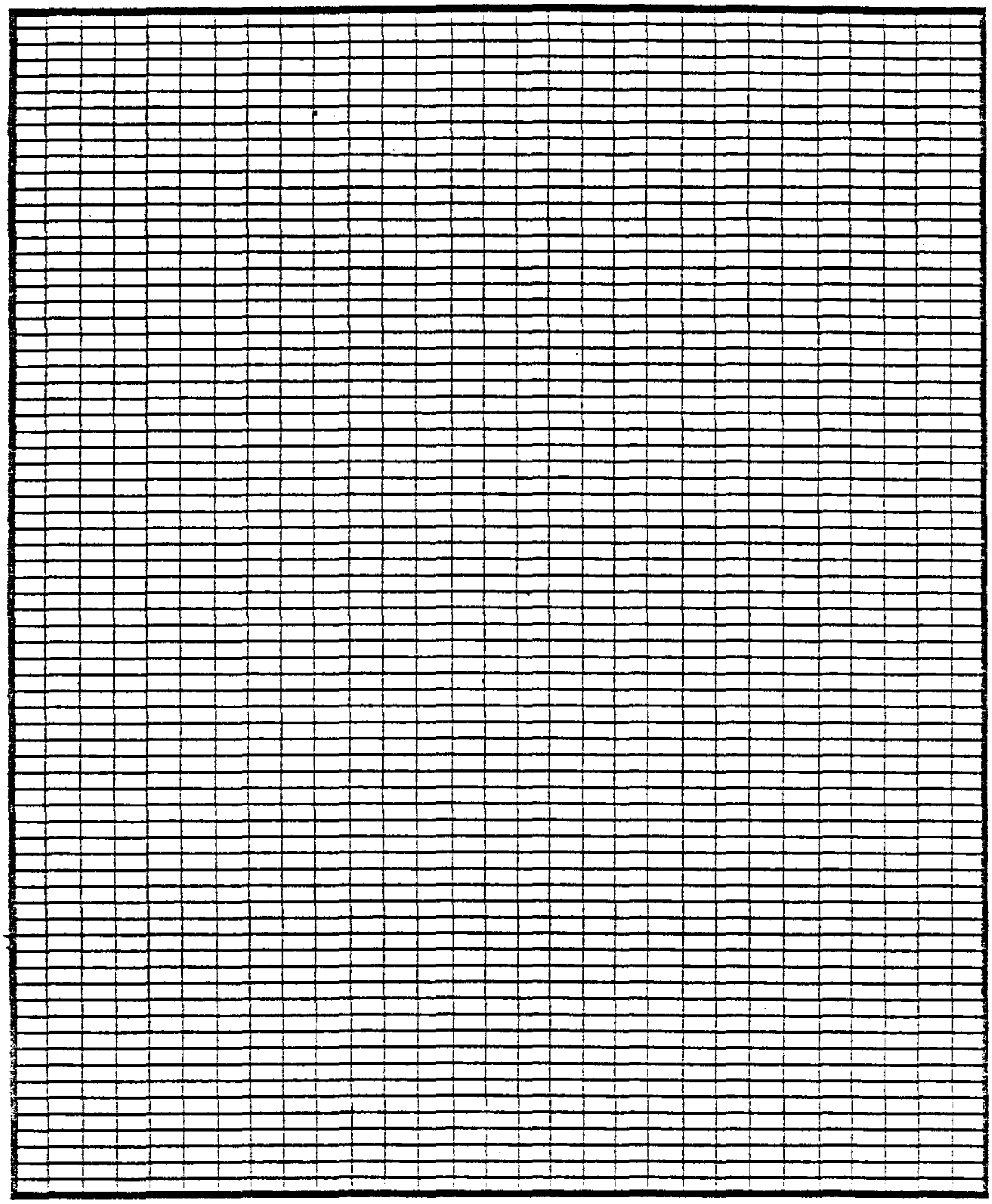


Figure 6

WATER DRAWDOWN LEVEL Well No.________

Month____________ 19___

FEET

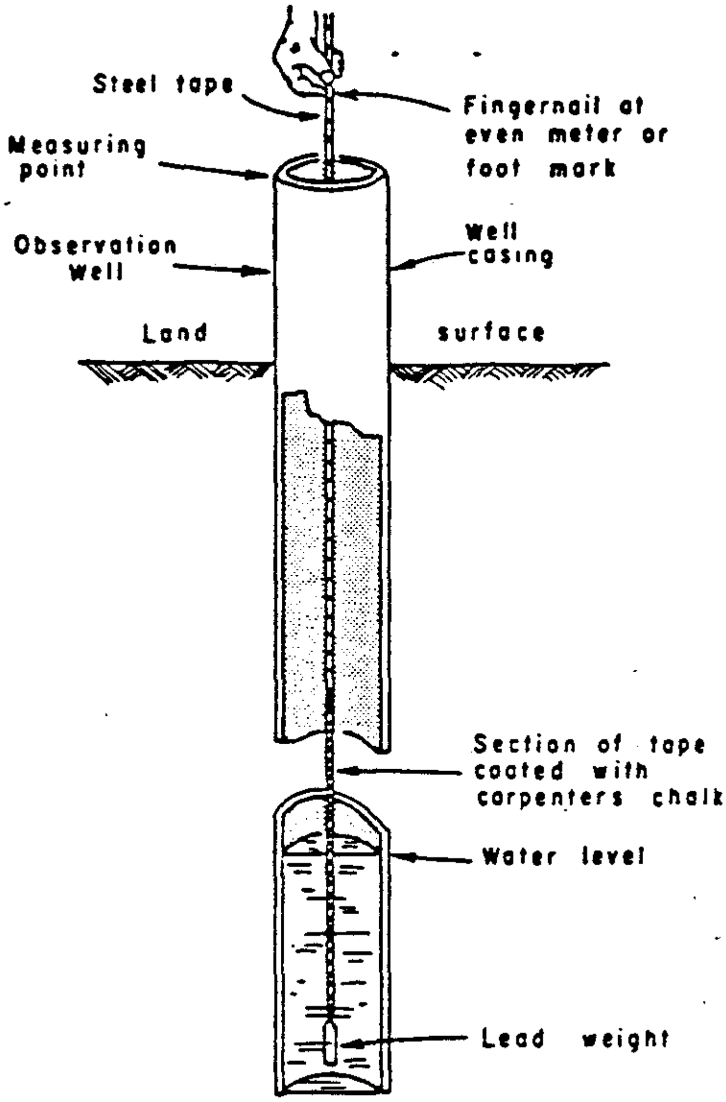


1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 23 24 25 26 27 28 29 30 31

DAYS

Figure 7

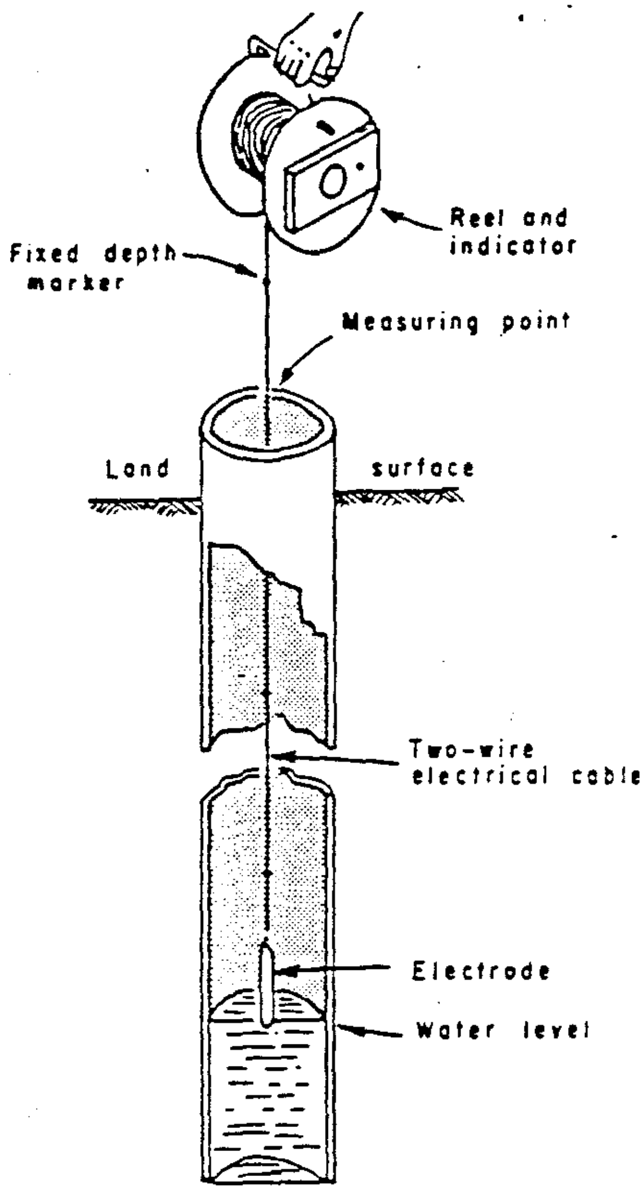
CHALKED TAPE Method for Well Water Level Measurements



From "Basic Elements of Ground-Water Hydrology with Reference to Conditions in North Carolina"; 1980; U.S.G.S. Open file Report 80-44

Figure 8

ELECTRIC TAPE Method for Well Water Level Measurements



From "Basic Elements of Ground-Water Hydrology with Reference to Conditions in North Carolina"; 1980; U.S.G.S. Open file Report 80-44

Figure 9

"An electric well measuring tape is basically a measuring tape with an electrode at the end." Lower it into the well and when the electrode touches water, the control will give a signal (a bell buzzer, light, or meter reading) (Wood and others, 1986).

Other methods for measuring water levels include pressure transducers and sonar devices.

Recording Water Levels

Plotting daily or weekly static water levels on a graph (Figure 6) will show trends in the amount of available ground water. Ground water levels will normally rise in winter and spring and drop in summer and fall. Keeping records of precipitation may provide information about the amount of ground water being recharged (Wood and others, 1986).

Plotting daily or weekly drawdown levels (Figure 7) will indicate when problems are developing with the well. When static water level stays constant but drawdown level drops, it indicates clogging or incrustation of the well screen or gravel pack which increases pumping costs and can reduce production. An abnormal drop in static water levels and specific capacity indicates a decreasing water supply and need for water conservation or restriction measures (Wood and others, 1986).

B. FREE FLOWING STREAMS AND SPRINGS

The measurement of springs and streamflows over a long period provides a statistical basis from which to predict flows and yields. The most frequently used low-flow statistic for unregulated streams and springs is a low flow which can be expected to occur over a three-day period once in twenty years. This streamflow value is referred to as a "3Q20." In Tennessee water management, the 3Q20 is recognized as a drought low flow. Wastewater permits are issued to users based on the 3Q20 low flow. It is the recognized standard by which managers measure risk, since water suppliers withdrawing amounts exceeding the 3Q20 for a stream are considered exposed to a level of risk which is unacceptable. It is also significant from an environmental standpoint. It is the stream flow value in Tennessee where water withdrawers must be alert to their potential impacts on fish and aquatic life habitat (Keck, 1987).

Determining Flow

If there is a flow gage near the system's intake, determine the flow at the gage in millions of gallons per day (mgd). To find mgd from cubic feet per second (cfs), multiply cfs x 0.646 (Wood and others, 1986):

Million gallons per day (mgd) = cubic feet per second (cfs) x 0.646

If a stream or discharge adds flow between the intake and the gage, or user removes water from the stream, figures must be adjusted accordingly. If the gage is downstream of the intake, adjustments must be made for discharges (a sewage treatment plant, for example) and for the system's withdrawal (Wood and others, 1986).

If a gage is not present, flow measurements should be made. Because of user patterns, it is important that flow measurements be made at the same time of day and same day of each week (generally on a week day). The measurements will require two people, sufficient line to cross the stream twice, an orange or a bottle partly filled with water, stakes, tape measure, stopwatch, paper, and pencil (Wood and others, 1986).

The measurement area should have well-defined banks. The stream bed should be fairly straight, easily accessible, with a flow having as little turbulence or riffle as possible. Often a site at or near the water supply intake is best. The site should not be in the pool area of a dam (Wood and others, 1986).

Two lines should be strung from bank to bank, at least 10 feet apart. The distance should be such that an object takes at least 20 seconds to float from one line to the other. After the stream's width has been measured between the two lines several depth measurements along the midway line should be made (see Figure 10, "Diagram of Physical Stream Measurements"). The average of the depth measurements should be computed. For example, if three depth measurements are taken (Wood and others, 1986):

$$\text{Average depth} = \frac{(\text{depth 1} + \text{depth 2} + \text{depth 3})}{3}$$

Multiply the average by the stream width to find the area of the cross-section of the stream.

Average depth (ft) x width (ft) = cross-section in square feet (sq. ft)

NOTE: The stream width should be broken into subsections if the stream is very wide or if the rate is not uniform across the section. Figure the cross-sectional area for each subsection separately.

An orange or partially filled water bottle should be dropped far enough upstream that it has settled into the streamflow when it gets to the first line, its "starting point." Measure the object's travel time from one line to the next. Determine rate of flow by dividing the distance between lines (in feet) by the travel time (in seconds) (Wood and others, 1986):

$$\text{Rate in feet per second (fps)} = \frac{\text{distance (ft)}}{\text{time in seconds}}$$

To obtain the best results, the object should be floated from three locations. The average speed should then be used. If subsections are used, get average rates for each subsection.

The discharge rate, in cubic feet per second (cfs), is calculated by multiplying the rate by the area.

Discharge rate in cubic feet per second (cfs) = rate (fps) x area (sq. ft.)

The discharge rate should then be multiplied by 0.85. This is a standard correction for the non-linear nature of flow in streambeds (Wood and others, 1986).

Diagram of Physical Stream Measurements

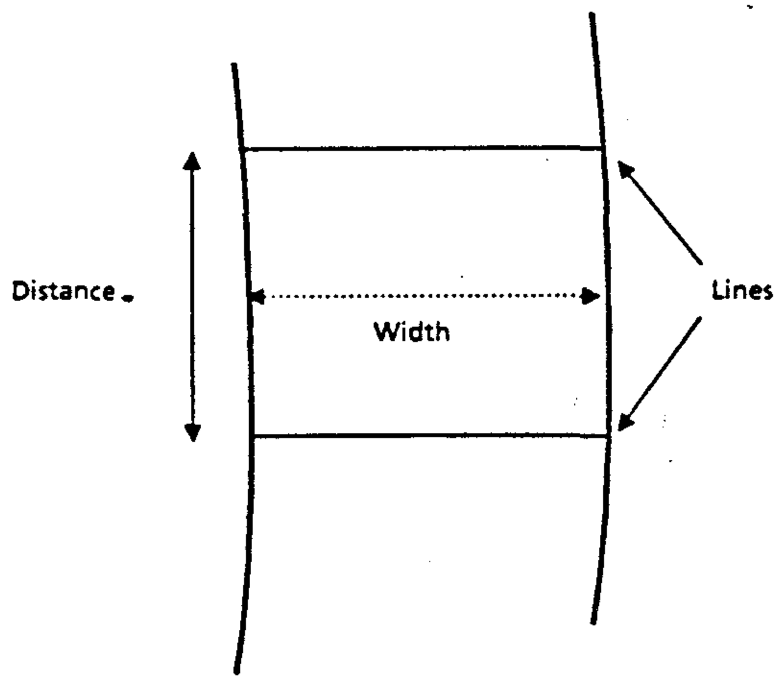


Figure 10

$$\text{Adjusted cfs} = \text{cubic feet per second (cfs)} \times 0.85.$$

The system's available source supply in million gallons per day (mgd) can be obtained by multiplying the adjusted cfs by 0.646:

$$\text{Rate of flow of the stream (mgd)} = \text{adjusted cfs} \times 0.646$$

If subsections are used, flow rates in each subsection can be added together to obtain total stream flow (Wood and others, 1986).

Recording Flow

An individual measurement as has been described above is of value only for a period of hours, or a few days, after it is made. Individual measurements are not useless; however, if properly recorded to establish a flow record. A long-term record can reduce the total number of measurements which have to be made at a later date (Wood and others, 1986).

The first step in developing a flow record is to establish a permanent fixed gage (often called a staff gage) at the site where the measurements are to be made. A gage may be on a bridge abutment or the intake structure. It should be rigidly fixed and treated to withstand exposure to water. The gage should be marked as shown in Figure 11, "Staff Gage for Measuring Streamflow Level" and extend below the intake. The water level on the gage should be read to the nearest tenth of a foot. The values should be plotted on graph paper as shown in Figure 12, "Example of Graph of Streamflow Record" (Wood and others, 1986).

C. FLOW-REGULATED STREAMS

A flow-regulated stream is a stream that depends on the water released from an upstream reservoir or impoundment.

Determining Flow

If a flow gage is not located near the intake, estimate flow by using the methods explained in "Free-Flowing Streams and Springs" section of this guide. If a gage is present, determine the flow at the gage in million of gallons per day (mgd). To calculate mgd from cubic feet per second (cfs), multiply cfs x 0.646:

$$\text{million gallons per day (mgd)} = \text{cubic feet per second (cfs)} \times 0.646.$$

If another stream or discharge adds flow between the intake and the gage, or another user removes water from the stream adjust streamflow figures by estimating the amount of water usually withdrawn between the upstream reservoir and the system's intake. Some users (farmers, for example) will be using larger amounts of water under dry conditions. Also, adjustments must be made for streams adding to the source between the dam and the system's intake. If there is a gage downstream of the intake, adjustments must be made for all discharges (a sewer plant, for example) and all withdrawals between the two. (Wood and others, 1986)

Staff Gage for Measuring Streamflow Level

(1) Alternate colors from orange or red to white at one-foot (1') intervals.

(2) Add black squares alternating sides at three-inch (3") increments.

(3) Mark the distance in feet above the bottom of the gage just above where each color change is made.

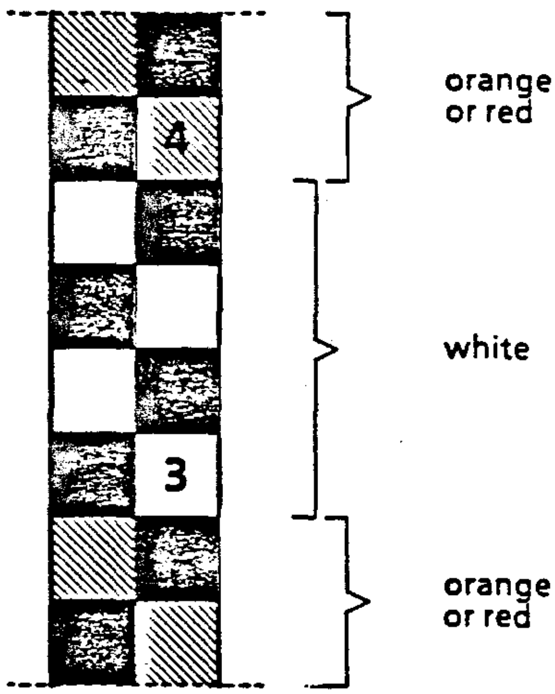


Figure 11

This diagram shows a section of a sample staff gage. Installing a staff gage can save much time and trouble once a flow record has been graphed from flow measurements and staff gage readings.

Example of Graph of Streamflow Record

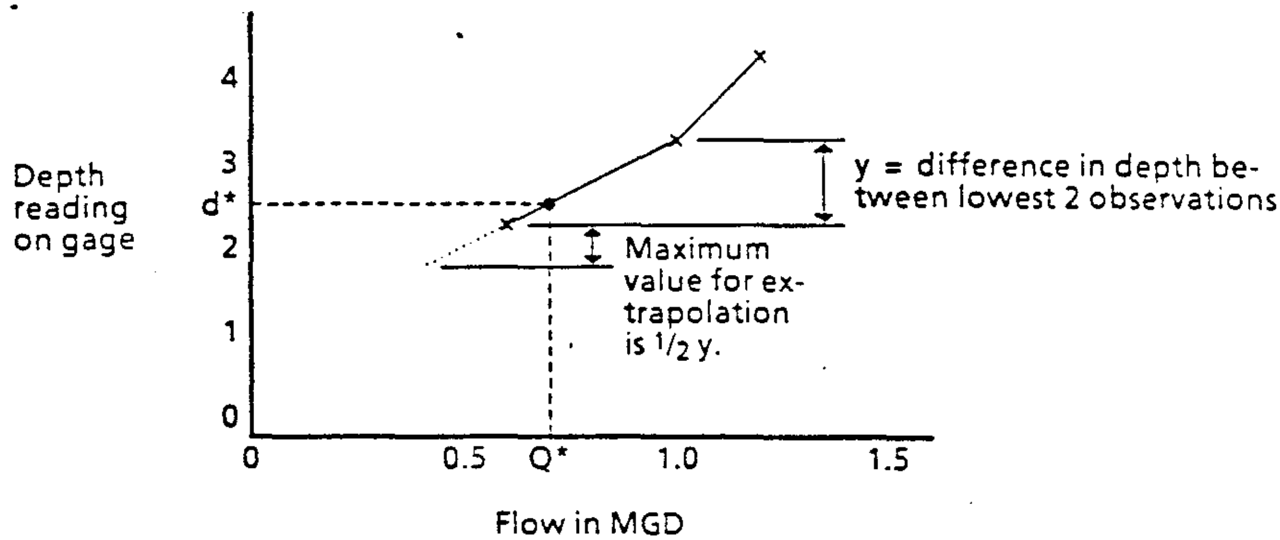


Figure 12

Only a few points have been graphed in this example; nevertheless, when the gage reading (d* in the example) is between previously plotted points, a new value of flow (Q*) is revealed, without further measurements, by a straight line relationship between the two known points. After a number of measurements have been made, the points may form a curve (Wood and others, 1986).

Increasing Flow Releases

The Army Corps of Engineers and Tennessee Valley Authority control the water releases affecting many streams in Tennessee. If potentially affected, water users shoud contact the appropriate agency or the Tennessee Office of Water Management to obtain information on their policy on low-flow releases. Users adversely affected should consult with the Tennessee Office of Water Management on changing the amount of water released during shortage conditions. In some instances, the volume of water released can be increased accomodate downstream users (Wood and others, 1986).

D. RESERVOIRS AND IN-STREAM IMPOUNDMENTS

Determining Volume of Available Storage

The number of gallons of **available** water in a reservoir can be estimated; the amount should take into account the fact that water below the level of intake pipes is not immediately available, and that sediment decreases volume. If information is not available on the volume lost to sedimentation, one-half of one percent of the design volume for each year since its construction should be subtracted (Wood and others, 1986).

The Tennessee Office of Water Management may be able to provide information on the original volume of the reservoir. Where a system obtains water from a Tennessee Valley Authority or Army Corps of Engineer reservoir, the water system manager should contact the Federal agency responsible for its operation. Although water below the level of a system's intake is not immediately available, it may be made available with intake modifications, auxiliary pumps and pipelines, etc. These actions should follow all the proper legal and institutional arrangements.

Monitoring Flow Out of the Reservoir

The amount of water flowing over the dam or spillway should be compared with normal seasonal flows. Flows should be monitored and recorded on a regular basis. The volume of water flowing into a reservoir less that being spilled should indicate any needed reservoir water management with respect to inflows, withdrawals, evaporation, and other factors (Wood and others, 1986).

Monitoring Flow Into the Reservoir

If the reservoir is estimated to hold more than a 30 day available supply, monitor upstream flow regularly. If the capacity of the reservoir is less than a 30-day supply or has receded to less than a 30 day supply, measure the amount of upstream flow on a regular basis using the methods described in the "Free Flowing Streams and Springs" section of this Guide (Wood and others, 1986).

The volume of water available should be divided by the projected daily demand to determine the number of days of supply left.

$$\text{Supply (days)} = \frac{\text{volume of available water stored (mgd)}}{\text{projected use (mgd)}}$$

Adjusting Supply Days with Incoming Streamflow

If the reservoir is holding less than a 30 day supply, the supply figure should be adjusted to account for springs below water level or by incoming streamflow.

The first step in adjusting supply days is to determine percent of demand being met by incoming flow. Divide inflow by projected use and multiply times 100.

$$\text{Percent of demand met by inflow} = \frac{\text{streamflow (mgd)}}{\text{projected use (mgd)}} \times 100$$

Secondly, determine the percent of demand met by water held in the reservoir.

Percent of demand met by reservoir = 100-percent of demand met by inflow (%).

Thirdly, determine what this means in gallons:

$$\text{Amount of demand met by reservoir (mgd)} = \text{demand (mgd)} \times \text{percent demand met by reservoir (\%)}$$

Finally, divide the volume of water stored by the demand being met by the reservoir to determine supply days left.

$$\text{Supply (days)} = \frac{\text{Volume of available water stored (mg)}}{\text{Amount of demand met by reservoir (mgd)}}$$

For example, if reservoir has 60 mg available, and the system expects to use 2 mgd, there is 30 days stored. If daily stream inflow is 0.60 mgd, the system is replenishing 30 percent of its supply daily. Therefore, the reservoir will recede at the rate of 70 percent of the daily demand, or 1.4 mgd. The adjusted available supply is then 60 mg divided by 1.4 mgd or 42 days (Wood and others, 1986).

Allowance must also be made for evaporation. Evaporation losses from a reservoir during drought depend on surface area, wind speed, air temperature, relative humidity, and sunlight. Because of the variableness of these factors, the evaporative rate is not a constant figure; it is generally lower in winter and greater in summer. The annual average amount of precipitation lost by evapotranspiration in Tennessee is about 60 percent. The daily loss from a reservoir by evaporation may be calculated by taking 75 percent of pan evaporation (Class A Land Pan) over any given period (Kazmann, 1965). On an annual basis evaporation losses from reservoirs are 28 to 30 inches in East Tennessee, and 30 to 35 inches in Middle and West Tennessee. Unfortunately, the largest losses from reservoirs occur when supplies are needed most.

E. INTERCONNECTIONS WITH OTHER UTILITIES

One of the best means of insuring adequacy of water supplies is to interconnect with other utilities, either for untreated or treated water. Interconnections allow a utility with water to help a system that is experiencing shortages. Primary considerations are the distance between the systems, the amount of water that would have to be transferred, the price paid for water that is transferred, sharing costs for the water line connecting the systems and pertinent legal and institutional considerations. It is far better to have the line in place prior to a drought or an emergency than attempt hurried construction when the need is greatest (Smith and Lampe, 1982).

The first step in developing an interconnection is to identify a nearby utility with water supply capabilities beyond its own needs. Contact the utility to see whether an agreement can be reached on sharing water during shortages. "A formal contract should be negotiated that specifies how much water each utility can use and the price that must be paid for the water." The utility with the need for extra supplies should pay for construction of the interconnection line and any additional pumping facilities. Plan design for the interconnection must be submitted to and approved by the Division of Water Supply before construction is begun. Such approval will be given high priority and should not take more than a couple of weeks in an emergency situation. If possible, interconnections should be built prior to the onset of drought, but, if necessary, can be built when the need arises. The design and construction of the line will probably take several months so practical use of this option depends on action being taken before the drought or other emergency occurs (Smith and Lampe, 1982).

Probably the greatest obstacle to interconnections is political in nature. Many utilities have difficulties negotiating agreements with other utilities. It is often difficult to agree on sharing water during shortages, price to be paid under these circumstances, and distribution of costs for new pipelines and pumping facilities (Smith and Lampe, 1982).

F. MONITORING WATER SOURCES

Once source capacities are known from collected data, continued monitoring of sources may be necessary, though not on an intensive, on-going basis. Regular monthly or weekly measurements are adequate most of the time. Once a drought alert is issued, or source conditions approach critical levels, more frequent monitoring of sources should be initiated. Depending on the source, its assessed capacity, and the "triggerpoints" identified by the system for initiating particular actions, the source may be measured weekly, daily, or even hourly. The monitoring program utilized by the water supplier will depend on the source and the extent to which it fluctuates.

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VII. ASSESSING DEMAND

During drought, many utilities experience problems related to overall system balance. A common problem is shortage of raw water due to source inadequacy or significantly greater water demands. A system must estimate essential, average, and peak water supply needs to assess its management potential. Common problems resulting from unchecked peak demands include low distribution pressures caused by small distribution mains and inadequate elevated storage, and well deterioration from overpumping (Smith and Lampe, 1982).

Other potential problems resulting from excess demand include bad tastes and odors from algae growths at low reservoir levels, shortages of treatment chemicals, and increased mineral content of water. Calculating a potential demand for water determines the criteria necessary for sizing water supply facilities. It is also used to predict what components of the system are likely to fail (Smith and Lampe, 1982).

Most systems should be capable of meeting short-term peak demands. Some systems may be capable of meeting longer term peak demands without imposing conservation or restriction measures. Analyzing a system's demand by user groups and sub-components and knowing each subsystem's capacity to deliver water are important in understanding a system's potential under certain restrictive measures.

When water supply systems are being designed, the sizes of various components of the system are based on the peak demands expected to be exerted on the system for a particular situation or time periods. Components sized to meet maximum daily demands include water intakes, raw water pumps, wells, raw water pipelines, and treatment plants. Distribution lines are designed to supply the maximum hourly demands or fire fighting flows, whichever are greater. Distribution pumps and system storage, both elevated and ground, are sized on the basis of the most severe combination of normal maximum demands and fire flows (Smith and Lampe, 1982).

Design engineers usually estimate future water demands by finding the persistent demand patterns.

- First, systems should calculate past average annual per capita demands for water and project them forward to the desired date. They should then estimate the population to be served by the utility in the future. Average annual demand to be met by the utility is the product of the estimated per capita demand and the projected population served (Smith and Lampe, 1982).

  The estimated per capita demand should be analyzed carefully. Local water usage practices vary with the use of garbage disposals and diswashers, percentage of homes with swimming pools, number of bathrooms per home, the importance of landscaping and water conservation, rate structures, etc. Current usage should be compared with historical usage and if trends are applicable, future estimates of per capita use may be used.

- Maximum daily and hourly demands are determined by multiplying the predicted average annual demands by appropriate maximum demand ratios (Smith and Lampe, 1982).

Where historical demand data for a utility are adequate, these maximum demand ratios are usually based on past demand patterns. If the historical demand data is not adequate to assess maximum demand patterns, standard maximum demand ratios are used (Smith and Lampe, 1982). The drought of 1985-86 may be used to determine the potential impact of a future drought.

Standard peak demand ratios (the ratio of peak demand to average demand) used by consultants in Kansas are also shown in Table 1, "Comparison of Maximum Demand Ratios." For periods of one day or longer, maximum demands experienced in 1980 for several surveyed cities in Kansas were actually somewhat higher than those predicted in Table 1. Water supply systems may be underdesigned where demand assumptions were not correct. Theoretical predictions of demand can be wrong (Smith and Lampe, 1982).

Table 1. Comparison of Maximum Demand Ratios*

Period	Maximum Demand Ratios (Peak/Average Annual) From 1980 Data	From Consultants
1-hour	3.11	3.3
1-day	2.31	2.1
7-days	2.06	1.7
1-month	1.83	1.4
2-months	1.60	---

*(Smith and Lampe, 1982.)

To project a system's average daily demand, demand data should be assembled for the utility to determine per capita demand. Table 2, "Average Per Capita Demands, 1977-1981" summarizes average per capita demands data from various utilities in Kansas.

Table 2. Average Per Capita Demands, 1977-1981*

Period	Year 1977 (gpcd)**	1978 (gpcd)	1979 (gpcd)	1980 (gpcd)	1981 (gpcd)
1-hour	482	513	475	592	458
1-day	296	316	285	374	302
7-days	270	278	245	348	251
1-month	225	245	208	302	214
2-months	193	207	191	260	197
Annual	157	168	168	180	---

*(Smith and Lampe, 1982)
**GPD per capita

Note that for this hypothetical city, demand was approximately 12 percent higher in 1980 than in the previous 3 years. The increased demands during the 1980 dry spell were probably caused by large uses of water for lawn, shrub, and garden watering. As seen in this table, demand can radically increase when the weather is dry.

Demand should be projected from past records and adjusted for new development. With an estimate of population growth, utilities can project average daily demand and maximum demand (using the maximum ratio). However, a utility should recognize that large industrial uses can cause per capita demand values to be higher than they would otherwise be.

Where industrial demands are a large percentage of total use, projected demand ratios are often too low, because most industrial demands are relatively constant. The projected data assume that the future percentage of manufacturing employees served by the utility would be the same as the current percentage. But this depends on the degree and type of industry attached and served. Planners need to consider what local industries are presentand how they use their water to see if corrections should be made to their projections of •demand.

- A third calculation that should be made is essential water use needs. Average water use demand in Tennessee ranges from about 60 gallons per capita per day to over 250 gallons per capita per day (gpcd). Average daily domestic water use in 1975 in the United States equaled 118 gpcd - 87 gallons inside the home and 31 gallons outside. This varies from system to system depending on local water usage practices, i.e., the use of appliances and fixtures using water, etc.

An effort should be made to determine what the minimum per capita usage will be where uses are curtailed. During brief emergencies, commercial and industrial demands can be severely restricted or eliminated, leaving the system only domestic requirements. For example, the knowledge that 40 gallons per capita per day is reasonable usage for a particular system during a brief emergency provides a basis for managing the water supply. For prolonged water shortage, utilities might plan for essential water use needs equaling 50 gallons per capita per day (Smith and Lampe, 1982).

If absolutely necessary, water use can be restricted to much less than 50 gallons per person per day, perhaps as little as five to ten gallons per capita per day. This is the amount of potable water needed for drinking, cooking, and minimal sanitation. The system should also estimate the amount of water needed to serve hospitals, nursing homes, to decontaminate lines, and to fight fires. These extreme measures are sometimes justified for sudden, severe emergencies such as tornadoes and floods (Smith and Lampe, 1982).

Since droughts develop over long periods of time and utility managers can observe water levels falling in reservoirs or wells, there should be time to implement conservation and restriction phases (Smith and Lampe, 1982). Sudden implementation of drastic measures should not apply to droughts as they do to other emergency situations.

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VIII. IDENTIFYING MANAGEMENT TRIGGERPOINTS

Droughts and other emergencies as well affect systems and users differently, depending on their source, system design, extent of the drought or emergency, and other factors. What constitutes a drought for one system may not be a drought for another. It will relate to a system's specific source or sources, degree to which facilities are developed, patterns of water use, water quality, water rights, economic and envrionmental considerations, and other factors.

Each supplier must evaluate his own source(s), treatment, delivery capacities, and uses. Following the evalution, each must identify appropriate triggerpoints for the various phases of drought management, including monitoring of drought conditions and water demand patterns. A triggerpoint is a preset condition at which point particular action is taken. Triggerpoints are based on some measure of water shortage, such as deficiencies in rainfall and runoff, decline in soil moisture, reduction in ground water levels, increase in daily demand, reduced storage, or some other appropriate condition. A triggerpoint should correspond to some measure of the system's delivering capability. It should be based on an assessment of the system's ability to meet continuing demand, given deteriorating resources and the potential for serious consequences if demand is not further managed.

For example, it may be determined that "Conservation" should begin when raw water storage is insufficient to meet the anticipated sixty-day demand at the current rate of usage. The plan might impose "Restrictions" when water use under "Conservation" exceeds the anticipated thirty-day supply and might call for "Emergency" measures when restricted water use exceeds the five-day supply. These actions, based on appropriate triggerpoints are responses which can be taken by a system to avert or prevent more severe cutbacks in deliveries to customers should the system's long-term expectations concerning supplies hold true.

Figure 2, "Balancing the Water System's Supply and Demand," summarizes those factors which should be considered in establishing a system's triggerpoints. When the system and not the source is at capacity the triggerpoints must be based on demand. However, where deliverable capacity is limited due to source considerations, appropriate triggerpoints will be based on source factors. Most triggerpoints will involve both. Various indices may be appropriate.

Using a rainfall based index may not be practical where water supplies appear to be adequate, unless usage is directly related to rainfall and supplies are threatened. In essence, the water supplier and its users must consider what constitutes a drought, the conditions in a drought, where more intensive management is needed, and the point at which it becomes an "emergency." There must be a definition of "emergency" that applies whether supply difficulties occur suddenly, or whether they occur slowly over time. Some managers may call anything from a break in the water main to a nuclear holocaust an "emergency." Obviously, emergencies differ in seriousness and scope and may also be classified.

A local water supplier may want to classify emergencies according to situations that demand different levels of response. Suppliers may distinguish between emergencies by first looking at their scope. What is the nature of the problem? Are the impacts confined and local, or are they regional? Can the problem be addressed at the local level or does its resolution involve others?

Emergencies might be further classified into three types: Class I, II and III. A "Class 1 Emergency" might be an emergency that can be handled on the local level and is a temporary crisis. It may include such "routine emergencies" as a break in a water main, a chemical spill, or loss of a pumping station. It may involve only a limited area. It may require some outside assistance, but the local system is able to control the situation.

A "Class 2 Emergency" might address the shortage of chemicals, or loss of water to a service area or a disaster affecting larger areas and greater lengths of time. This situation may be any that lasts 2 days to a week. It would include those situations clearly beyond the ability of the local system to relieve within a reasonable period of time without considerable outside aid. A "Class 2 Emergency" may require coordinated responses from a regional or larger framework. Local resources will have been expended.

A "Class 3 Emergency" may include more restrictive measures for truly extreme situations. Water supplies are cut off to most customers. Outside help is needed to restore water supply. System wide reductions of over 80 percent are required.

Responses to linebreaks, floods, chemical spills, power outages, etc. should be developed and included in the "Emergency Operations Procedures" portion of the water system's drought and emergency management plan.

When planning for the **management of emergencies**, it is essential to identify resources for which there is a potential need. Once needs are identified, the plan should also identify potential providers, i.e., trucking companies, nearby cities, industries, etc. In some instances, contractual arrangements may be developed for implementation during emergencies.

Responses to each class of emergency should be planned by management similar to "phases" of a drought management plan. These considerations should be addressed at the local level, by the local water supplier. Each management phase or class distinction should be based on an appropriate set of criteria suited to the circumstances of the water supplier. Estimate probable levels of supply in the short-term and compare the supply forecasts to short-term forecasts of restricted and unrestricted water demand (Planning and Management Consultants, Ltd., 1986).

The unrestricted peak demand during a shortage situation may be different from "normal" conditions. Demand forecasting models for specific service areas can be taken from historical data on water use and weather conditions. Both the supply and demand forecasts should be statistical (Planning and Management Consultants, Ltd., 1986).

A. SYSTEM HYDRAULICS

The hydraulic capacity of various system components should provide excellent indices that may be used to trigger management activities. Obvious component failures, such as linebreak, or pump failure, caused by a landslide, earthquake, power outage, accident, etc. should prompt the immediate implementation of appropriate emergency operations procedures (EOPs). (Refer to the Division of Water Supply's "Guidelines for Emergency Operations Planning for Community Water Systems.") In drought management, the capacity of system components including the treatment plant, a booster pump serving an area, and water storage facilities provide other triggerpoints.

For example, certain restrictive measures may be necessary when the capacity of a system subarea is extended beyond its capacity to deliver due to major firefighting requirements. Other hydraulic limitations may be suggested by diminishing finished water supplies in storage.

Figure 13, "The Effect of Water Use on Storage," illustrates the relationship between forecasted supply and demand for a system having an impoundment. In this illustration, both the system's peak demand and average daily demand exceed the 3Q20 inflow. Forecasting water demand under these two levels of use and forecasted supply reveals very different outlooks. Instead, the impoundment could be the system's 3-day storage and the 3Q20 could be the treatment plant capacity. Management, then, might need to be triggered on the basis of system hydraulics. Where a system's hydraulics are under stress to deliver or maintain deliveries over a foreseeable period, a triggerpoint based on water demand would be appropriate. If targeted reductions were not achieved, the next more restrictive phase would be triggered. It is essential that water supply systems balance source supplies and manage water demand looking at the future implications of their decisions.

B. RAINFALL AND EVAPORATION

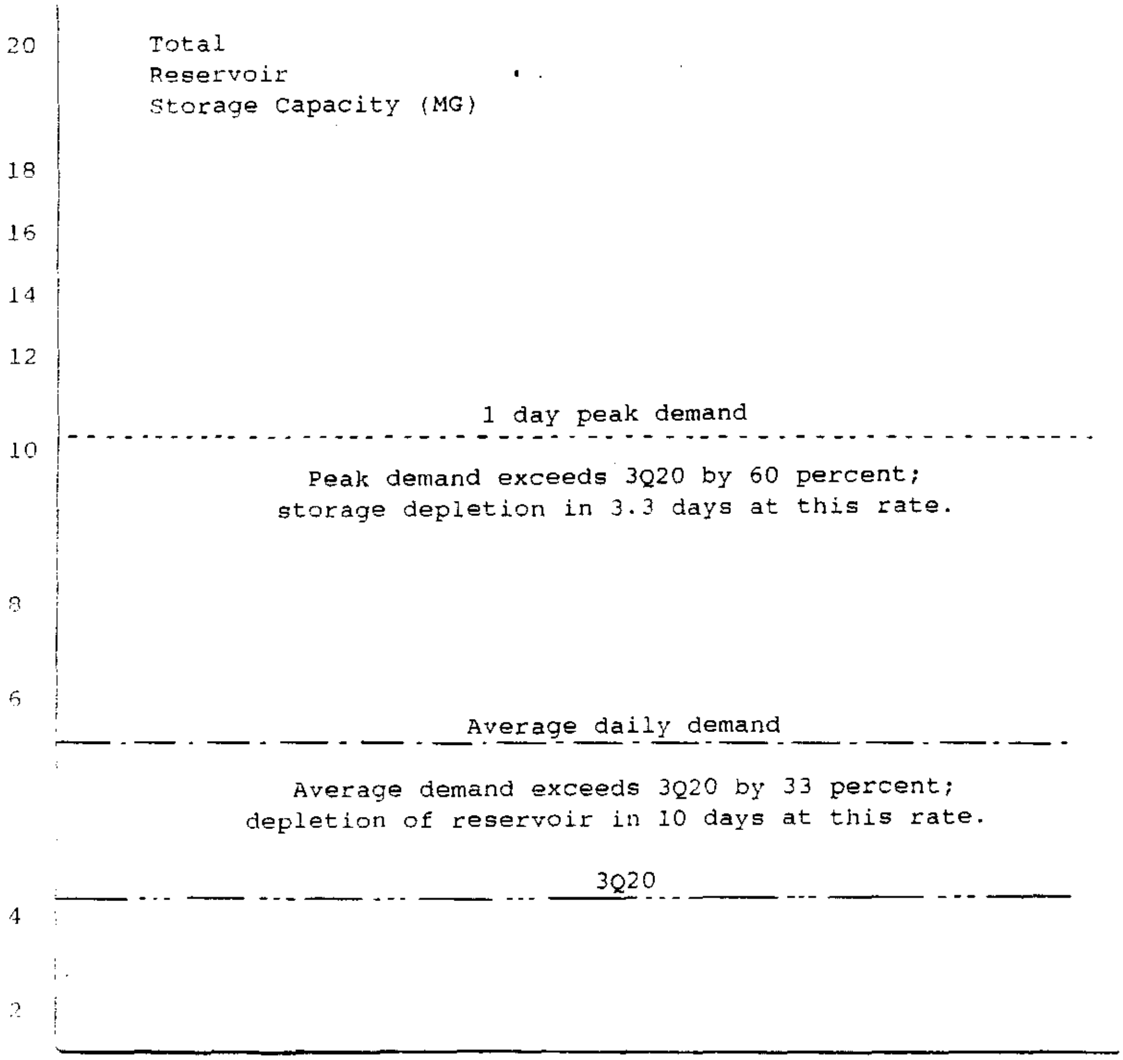
Various rainfall-evaporation related indices may be used by the state, a county, or local water supplier to trigger activities of a water management phase. They may not be suitable as a triggering mechanism for many water suppliers. On the other hand, a rainfall-related indice may correspond to increased outdoor demand. These drought indices are frequently based on water supply variables such as precipitation, temperature, wind velocity, radiation exposure, streamflow, soil moisture, ground-water levels, etc. either in individual or combined form, or combined with water-demand variables. Many different factors may be included in analysis of drought phases.

"In Texas, for example, periodic map analyses of rainfall distributions are used to identify abnormally dry areas during the previous 30-day and 60-day periods by comparing these data with normal rainfall patterns. In Texas, the degree of drought is determined as follows" (Rouse and others, 1984):

> Partial meteorological drought--a condition characterized by a rainfall amount less than 50 percent of normal for a 30 day period (normal is the 30-year average ending last decade year, i.e., 1980).
>
> Meteorological drought--a condition characterized by a rainfall amount less than 50 percent of normal for a 60-day period.

Figure 13

The Effect of Water Use on Storage



Storage depletion schedule varies according to management of use at a 3Q20 flow.

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"In South Dakota, the Drought Analysis and Assistance Office is activated when a substantial portion of the state has received less than 50 percent of normal rainfall in the previous 30 days, or if within the last 60 days, a substantial portion of the state has received less than 75 percent of normal rainfall" (Missouri River Basin Commission, 1981). Other rainfall related indices, "such as the National Fire Danger Rating System and the drought index used by the U.S. Department of Agriculture (1968) in forest fire control, may also be utilized for verification purposes or as supplemental information" (Rouse and others, 1984).

In Tennessee, data collection consists of general indicator data. The Tennessee Office of Water Management monitors selected streams for flow data (obtained from the United States Geological Survey through its cooperative program). Stream flow data collected on a regular basis include: average mean monthly flow for the period of record, mean monthly flow for the current year, the maximum and minimum daily discharge for the month, and the calculated 3Q20. (A 3Q20 is the estimated low flow for a stream or spring which can be expected to occur over a three-day period once in twenty years.) Reservoir water level (obtained from the Tennessee Valley Authority and the U.S. Army Corps of Engineers) and ground water level data (collected by the United States Geological Survey) are also monitored. In addition, precipitation data (collected by the National Weather Service) is monitored by the Office of Water Management (Keck, 1987).

During a drought, precipitation, streamflow and groundwater data are collected and made available to the public on a regular basis by the Office of Water Management. When drought is regional in nature, the release of management information is targeted on a multi-county or regional basis.

When appropriate, the Office of Water Management issues a local, regional or statewide "Drought Alert." The alert is designed to call attention to users and suppliers of the need to evaluate hydraulic or source stress and the possible need to curtail water demand. During a "Drought Alert" the Office of Water Management through its regional field offices contacts weekly those water supply systems and industries in the targeted area considered "drought sensitive" or "having a potential for a shortage." Their status is monitored and technical assistance given to the extent possible, including the identification of alternative supplies.

At the local level, a county or water supplier may issue a "Drought Alert" based on similar, localized considerations. A local "Drought Alert" can be issued calling attention to the need for possibly more intensive management of suppliers at the local scale. Self-supplied domestic users, farmers, industries, and others may want to monitor their sources in particular.

When a "Drought Alert" is issued locally, the Office of Water Management should be informed. Where shortages, water quality problems, or other conflicts appear in source use, users should immediately notify the Office of Water Management for assistance. Alerts should signal the need to regularly evaluate a specific source or sources and the demands placed on those sources.

More sophisticated drought indices useful in issuing a "Drought Alert" or providing a basis on which to base management phases include: the Palmer Drought Index, the Crop Moisture Index, and various historical comparisons.

C. PALMER DROUGHT INDEX

The Palmer Drought Index (Palmer, 1965), the most commonly used rainfall-related index, "utilizes a supply/demand water balance accounting procedure in conjunction with climatic weighting factors to produce a drought severity indexing system. This index reflects the abnormality of moisture deficiency or surplus." Within this water balance, supply is represented by precipitation and stored soil moisture; while demand is expressed as potential evapotranspiration, soil moisture recharge, and normal surface runoff (Rouse and others, 1984).

"According to the Palmer method, drought is an interval of time during which the actual moisture supply at a given location falls short of the climatologically expected moisture supply. The drought is a function of both the duration and magnitude of the moisture deficiency. Specific index numbers of the Palmer system are as follows" (Rouse and others, 1984):

+4.0 or above	Extreme Moist Spell
+3.0 to +3.9	Very Moist Spell
+2.0 to +2.9	Unusual Moist Spell
+1.0 to +1.9	Moist Spell
+ .5 to + .9	Incipient Moist Spell
+ .4 to - .4	Near Normal
- .5 to - .9	Incipient Drought
-1.0 to -1.9	Mild Drought
-2.0 to -2.9	Moderate Drought
-3.0 to -3.9	Severe Drought
-4.0 or Below	Extreme Drought

Palmer Drought Index data is published weekly in the "Crop and Weather Bulletin" by the Climate Analysis Center, National Weather Service (NWS). Subscriptions to the "Crop and Weather Bulletin" are available at a nominal cost.

D. CROP MOISTURE INDEX

The Crop Moisture Index (CMI) adjusts computations produced by the Palmer Index to reflect moisture conditions which affect growing vegetation and field operations. "It is designed to respond quickly to changes in the upper layer soil moisture situation. The CMI is therefore an index of agricultural drought" (Rouse and others, 1984).

"The CMI can be used as an indicator of real-time agricultural conditions as well as a verification tool to supplement the Palmer Index" (Rouse and others, 1984). In Tennessee, soil moisture conditions are reported weekly during the growing season by the Agricultural Statistics Service, Tennessee Department of Agriculture. These data, although reliable, do not utilize the CMI. However, like the CMI, they take into account fieldwork conditions and crop yield prospects.

E. HISTORICAL COMPARISONS

A low soil moisture content is not always the first indication of events leading to a drought situation. If an area is receiving just enough precipitation to satisfy evapotranspirational needs of crops and vegetation, almost all moisture will be used to satisfy these demands. "During this situation, crops and agricultural activities might be progressing at near normal levels." However, very little water would run off to rivers and streams. This condition could be classified as "hydrologic drought" (Rouse and others, 1984).

The local water supplier can consider this kind of drought as a supplement to the Palmer Index. Recording gages located on unregulated streams accurately reflect precipitation runoff within a basin. During the verification procedure for a drought alert phase, real-time data from a stream gage network can be compared to historical data (Rouse and others, 1984).

Similarly, records of observations of ground water levels can be followed to see if such data are related to drought severity. Few records may be available for past water-use data, but water-use reporting for those using 50,000 gallons or more of water per day was initiated in 1972 by the Office of Water Management.

F. STREAMFLOW AND SPRINGS

Instead of using miscellaneous drought indices to base water management phases, a water supplier may choose to monitor the specific sources utilized by the system. Sources for most include unregulated streamflows, springs, impoundments, regulated streamflows, water wells, and connections to other systems. Each source will have its own unique triggerpoints.

"During droughts, run-of-river flows (unregulated streams) are more affected than surface impoundments or groundwater supplies." The supplier should assess the ability of a source stream to maintain flow during droughts. Signs of abnormally low supply from a free-flowing stream or spring can be determined by comparisons to historical records with adjustments for changes in use. If these are unavailable, a "Drought Alert" should be issued as demand approaches 40 percent of flow and conservation measures should be implemented when demand is 40 to 65 percent of available flow. Measurements should be made twice weekly. Once in effect, conservation measures should not be removed until demand is less than 40 percent of flow for a four week period. If demand is 65 to 75 percent of flow on a free-flowing stream or spring, a water shortage "Restrictions" phase should be declared. Once in effect, the "Restrictions" phase should not be lifted until demand is less than 65 percent of available flow for a four week period. Flows should be measured daily (Wood and others, 1986).

An "Emergency" should be declared when demand is 75 percent or more of available flow on a free-flowing stream. Flow should be measured daily. Once in effect, the "Emergency" phase should continue until demand is less than 75 percent of available flow for a four week period (Wood and others, 1986).

Systems on flow-regulated streams should activate a conservation phase when dam releases are cut or when demand is 65 to 75 percent of available flow. If dam releases are diminished further or demand is more than 75 percent of available flow, a "Restrictions" phase should begin (Wood and others, 1986).

The need for activation of the "Emergency" phase for systems on flow-regulated streams depends on the operational characteristics of the upstream reservoir (Wood and others, 1986). In activating this management phase, percentages might be considerably lower as the 3Q20 is exceeded.

G. IMPOUNDMENTS

The volume of water in storage at a given time may be used as the determining factor for a drought phase. Depending on this volume, storage may be normal in a "Drought Alert." Volumes of water in storage may be expected to change depending on the time of year (supply/demand relationships) (Pennsylvania Gas and Water Company, undated).

To indicate the stage of its storage, a water supplier could utilize a pictogram such as in Figure 14, "Reservoir Operation Curve," to illustrate the conditions of its storage. Figure 13 indicates a hypothetical utility's storage capacity in 1980-81 relative to the drought stages. Reservoir storage level reports are monitored on a regular basis (Pennsylvania Gas and Water Company, undated).

"During extended periods of below normal rainfall, storage volumes may be plotted on pictograms" as in Figure 14. This data, together with short- and long-range weather forecasts and other information, could be utilized by management to determine the stage of drought condition (Pennsylvania Gas and Water Company, undated).

Other factors which may need to be considered in an impoundment situation include intake elevation and water quality. Possible triggerpoints for systems relying on an impoundment should relate to the number of days supply remaining. Figure 13, "The Affect of Water Use on Storage," illustrates the benefits of water use management.

A potential shortage would exist when there are less than 60 but more than 45 supply days left. In some systems, a water shortage "Alert" might be warranted with an even larger supply. Supply should be reassessed weekly (Wood and others, 1986).

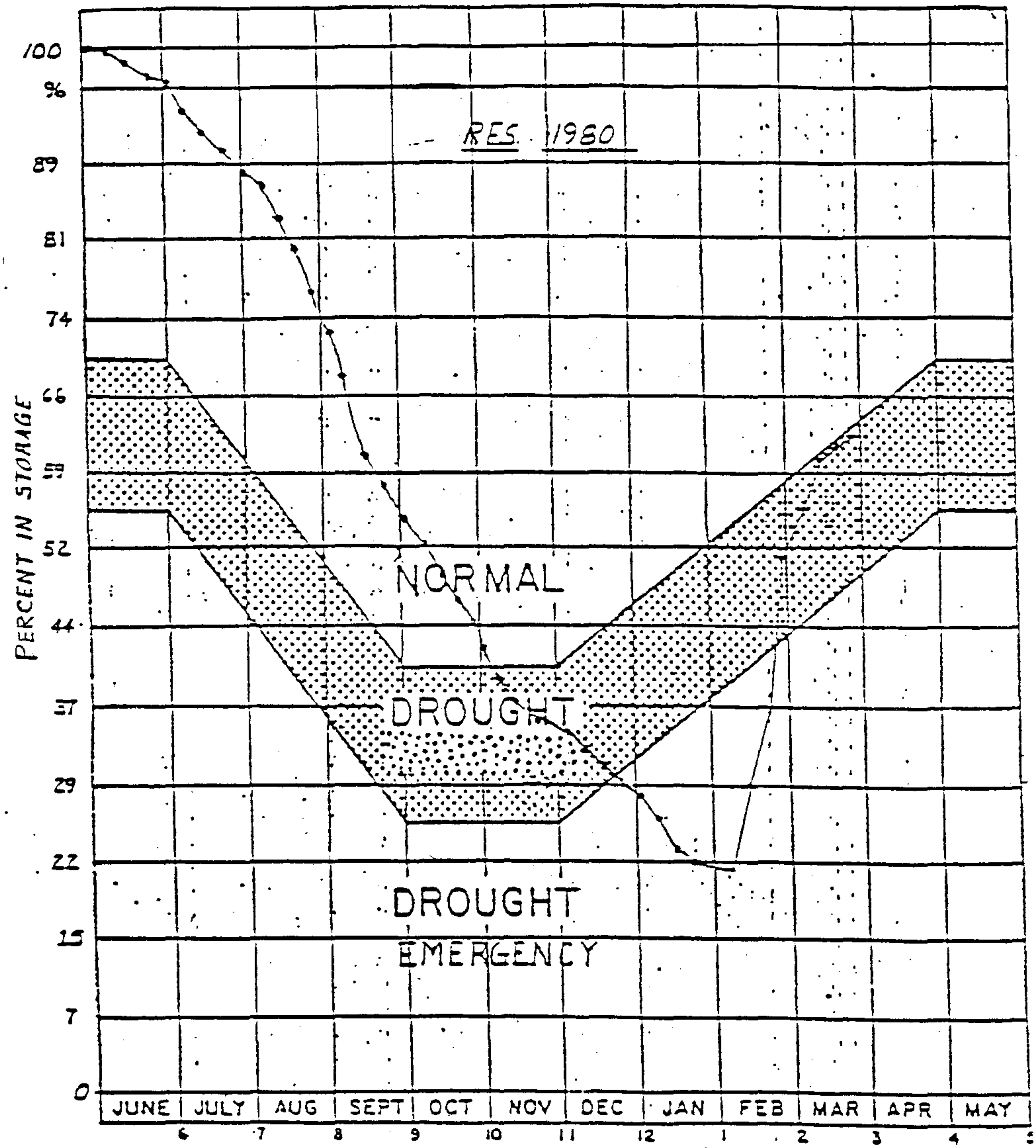
Activation of the "Conservation" phase should be declared when there are less than 60 but more than 30 days in a reservoir. Include incoming flow when making calculations, as explained in Chapter IV, "Assessing Source Capacity." Supply should be reassessed every few days (Wood and others, 1986).

Water "Restrictions" should be declared when there are less than 30 but more than 7 days available supply. Include incoming flow when making calculations, as explained in "Assessing Source Capacity." Supply should be reassessed daily. An "Emergency" should be declared when less than five days of supply is available. Include incoming flow when making calculations, as explained in "Assessing Source Capacity" (Wood and others, 1986).

H. WATER WELLS

Pump tests are used to measure water well capacities. These tests involve detailed analysis of area geology and other factors. In instances where a public water supplier obtains water from a well, an appropriate triggering mechanism can be the water level. Well measurements should be made at least weekly under normal conditions.

FIGURE 14



Reservoir Operation Curve

A potential shortage in a well would be suspected when water supply conditions in the area are especially low, or when another well which draws from the same aquifer is showing signs of reduced supply. It is also of concern when the static water level is decreasing faster than usual or when drawdown is (1) increasing faster than historically normal for the season, (2) increasing when it would normally decrease, or (3) changing quickly. In West Tennessee, in particular, a declining static water level may indicate the need for water conservation measures (Wood and others, 1986).

Signs of a shortage in a well would be an abnormally large or rapid increase in drawdown or a large decrease in static water level. This may indicate the need for restrictions. Measurements should be made daily (Wood and others, 1986).

I. INTERCONNECTIONS

The triggering mechanism for water suppliers with an interconnection to another system should be contained in the contract or agreement between the entities. Some contracts/agreements include requirements relating to the sharing of a water shortage or they may specify purchase limits and price levels under certain conditions. If a supplier obtains all of the system's water from another supplier and shortages are shared, the activation of the various management phases should coincide. Where a purchasing system is limited to specific amounts of water by agreement, independent triggerpoints may be required. Systems must develop their own triggerpoints based on a thorough evaluation of their circumstances.

J. MULTIPLE SOURCES

Water supply systems having multiple sources of water should also be evaluated. Systems with multiple sources must evaluate the capacity of each source, and weigh the impact of that source's failure on the remainder of the system. Each source must be considered for its contribution to meet the demands on the system. It would be inaccurate to tie water management to one source. Systems having a mix of sources, especially different types of sources (surface and ground water) which are also both reliable, may have advantages over single source systems.

K. WATER QUALITY

Where a water system experiences a linebreak, a loss of pressure, or a chemical spill occurs, potential water quality problems are obvious. The first steps in these instances are for the system to isolate the problem area, initiate a clean-up of spilled substances, if appropriate, or make repairs and implement temporary services, if necessary. The specific steps taken will depend on the emergency and should be outlined in the plan's emergency operations procedures (EOPs).

During a drought, water quality problems are also probable, particularly in streams and reservoirs. Streamflow is reduced, causing reservoirs to be maintained at lower levels. Reservoirs on tributaries to the Tennessee and Cumberland Rivers will be at lower levels than the mainstem reservoirs. Water users which withdraw from tributary reservoirs and smaller streams will be hardest hit by decreased amounts of water. Small, unregulated streams could stop flowing entirely due to decreasing water levels and runoff.

When streamflow is reduced, possible water quality problems are (1) higher temperatures, (2) lower dissolved oxygen, (3) higher algae production, (4) decreased assimilative capacities for industrial and municipal discharges, (5) taste and odor problems, (6) increased mineral concentrations, (7) and increased potential for biological pollution. In areas where water quality is already a problem, impacts of a drought will make problems more pronounced.

Although Tennessee is fortunate to have many reservoirs which are a tremendous help in times of water shortage, reservoir releases may be one source of water quality problems. Natural stratification in reservoirs causes different dissolved oxygen concentrations in different depths of the reservoir. During summer, dissolved oxygen at the bottom is normally at very low levels.

When low water levels in the reservoirs during summer combine with reduced inflow from runoff and increased retention time, dissolved oxygen concentrations become even lower than normal. When this water is released through low level turbines, downstream water quality suffers.

The low dissolved oxygen levels cause a chemical conversion of insoluble iron and manganese to more soluble forms. Releases of lower level water increase concentrations of manganese and iron in the water found downstream. These concentrations can cause an unpleasant color and taste in the water in public water supplies. In addition, both iron and manganese are undesirable in some industrial processes.

Dissolved oxygen in water is necessary for fish and other aquatic life. It is also essential to the stream's assimilative capacity, which is the ability of the stream to accept natural or man-made wastes and cleanse itself. Many types of bacteria use dissolved oxgyen in the decaying process. As more wastes are discharged, the limited amount of oxygen becomes even more depleted. With a decreased dilution capability for industrial and municipal discharges, higher concentrations of sewage bacteria will be found below the discharges of sewage treatment plants.

Deterioration of water quality usually increases the costs of treating raw water for drinking water purposes and water-based recreational opportunities are often reduced. More nuisance growths of algae and aquatic weeds occur because of nutrient enrichment, which lead to additional taste and odor problems. Fish kills may occur due to oxygen depletion and concentration of toxic substances.

Public water suppliers and the public need to be made aware of the water quality problems associated with a drought and identify those with a potential to impact their water supply. Public water suppliers should be prepared for the added treatment necessary to keep their supply in compliance with existing regulations.

Simiarly, up-stream discharges should be identified. Discharge sources having a potential for a chemical spill also should be considered in local plan preparation. Low-flows accentuate water quality problems. A more thourgh listing of responses to identified potential water quality problems is contained in Chapter X, "Dealing with Shortages and Water Quality Problems."

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IX. CLASSIFICATION OF WATER USES

Public water suppliers should develop a classification system of water uses to reflect water priorities. A classification system clarifies issues of fairness, hardship and, ultimately, management effectiveness. Some water uses are important only socially or economically. Some water uses are essential and some are non-essential.

These classes may be different from place to place based on differences in local priorities. Each water supply system must decide the degree to which they support these general classes under varying situations. These classes are useful in identifying goals, priorities, and strategies, as well as weaknesses of a drought management plan.

A public water supplier's plan should classify water uses, while considering all the water management options available; i.e., pricing, conservation, supplemental supplies, bans, etc. An effective drought management plan would emphasize or focus on curtailing one class of uses before strong measures are implemented to significantly cut the next higher water use classification. Classifying uses and analyzing their contribution to the system's overall demand may reveal a plan weakness. First Class Essential Water uses should always be provided for. Essential uses are further classified into Second and Third Class Essential Water uses. Non-essential Water uses should also be identified. The following are **recommended** water use classifications.

First Class Essential Water Uses (Wood and others, 1986)

Domestic Use:
- water necessary to sustain human life and the lives of domestic animals and to maintain minimum standards of hygiene and sanitation (sink only use, excludes laundry, commode, bath and shower uses),
- emergency shelters.

Health Care Facilities:
- patient care and rehabilitation including related pool make-up water (requiring less than 25 percent filling).

Public Use:
- firefighting,
- health and public protection purposes, if specifically approved by health officials and the municipal governing body, including line flushing on an emergency basis.

Second Class Essential Water Uses

All Domestic Uses Not Included in First Class:
- personal home water use includes water used in the kitchen for food preparation, commode, bath, shower, laundry, and landscape watering (handheld hose watering of shrubs before 8:00 a.m. and after 6:00 p.m.).

Agricultural Watering (which is publicly supplied):*
- agricultural irrigation at a minimum level for the production of truckcrops, the maintenance of livestock, and all drip irrigation;
- watering by commercial nurseries at a minimum level necessary to maintain stock, to the extent that sources of water other than fresh water are not available or feasible to use;

- water use by arboretums and public gardens of national, state, or regional significance where necessary to preserve specimens, to the extent that recycled water is not available or feasible to use;
- landscape (shrubs) and vegetable garden irrigation (handheld only);
- minimum watering of golf course greens.

Industrial Water Use (publicly supplied):
- industrial processes
- refer to industrial air conditioning below

Commercial and Public Water Use (publicly supplied):
- office, retail, entertainment, schools and churches
- laundromats, unrestricted hours of operation
- restaurants, clubs and eating establishments, unrestricted hours of operation
- motels, hotels and similar commercial establishments, unrestricted hours of operation.

Office and Industrial Air Conditioning (water cooled):
- refilling for startup at the beginning of the cooling season,
- make-up of water during the cooling season to maintain temperature no cooler than 78°F.
- refilling specifically approved by health officials and the municipal governing body, where the system has been drained for health protection or repair purposes.

*very little publicly supplied water actually may be used for agricultural purposes

Third Class Essential Water Uses

Schools and Other Institutions:
- showering facilities

Filling and Operation of Swimming Pools:
- residential pools which serve more than 25 dwelling units,
- municipal pools,
- pools used by health care facilities for patient care and rehabilitation requiring 75 percent or more filling.

Washing of Motor Vehicles:
- commercial car and truck washes.

Non-Essential Water Uses

Ornamental Purposes:
- fountains, reflecting pools, and artificial waterfalls.

Outdoor Non-Commercial Watering (publicly supplied):
- irrigating gardens (except handheld), lawns, parks, golf courses (except greens), playing fields, and other recreational areas;
- street, driveway, and sidewalk washing.

exceptions:
- agricultural irrigation at a minimum level for the production of truck crops or the maintenance of livestock, and all drip irrigation;
- watering by commercial nurseries at a minimum level necessary to maintain stock, to the extent that sources of water other than fresh water are not available or feasible to use;
- water use by arboretums and public gardens of national, state, or regional significance where necessary to preserve specimens, to the extent that recycled water is not available or feasible to use;
- landscape (shrubs) and vegetable garden irrigation (handheld).

Filling and Operation of Swimming Pools:

exceptions:

- residential pools which serve more than 25 dwelling units,
- pools used by health care facilities for patient care and rehabilitation,
- municipal pools.

Washing of Motor Vehicles:

- automobiles, trucks, boats and trailers.

exceptions:

- commercial car and truck washes.

Serving Water in Restaurants, Clubs, or Eating Places:

exceptions:

- specific request by a customer.

Fire Hydrants:

- any purpose, including use of sprinkler caps and testing fire apparatus and for fire department drills.

exceptions:

- firefighting,
- health protection purposes, if specifically approved by the health officials of the municipality,
- certain testing and drills by the fire department, if it is in the interest of public safety, and is approved by the municipal governing body.

Flushing of Sewers and Hydrants:

exceptions:

- as needed to ensure public health and safety, and approved by health officials and the municipal governing body.

Air Conditioning:

- refilling cooling towers after draining.

exceptions:

- refilling for startup at the beginning of the cooling season,
- make-up of water during the cooling season,
- refilling specifically approved by health officials and the municipal governing body, where the system has been drained for health protection or repair purposes.

The class of use targeted for actions may vary. One water supply system may only need to ban non-essential water uses and require cutbacks in other uses of water to meet its conservation objective. Another system may need to impose cutbacks only on its non-essential uses. Figure 15, "Recommended Water Use Classes and Class Restrictions," shows a typical scenario. Defining class restrictions insures consistent policies in the development of an emergency water management plan. To simply pick and choose among responses and policies without regard to potential benefits runs the risk of inadvertently cutting back on a high priority water use or allowing some lower priority use to continue as if there were not a water shortage.

Figure 15
Recommended Water Use Classes and Class Restrictions
(Wood and others, 1986)

General Water Use Class / Program Phase	Conservation	Restrictions	Emergency
Essential, First Class	Voluntary Cutbacks	Voluntary Cutbacks	Mandatory or Voluntary Cutbacks
Essential, Second Class	Voluntary Cutbacks	Mandatory or Voluntary Cutbacks	Mandatory Bans
Essential, Third Class	Voluntary Cutbacks	Mandatory Bans	Mandatory Bans
Non-Essential	Mandatory Cutbacks or Bans	Mandatory Bans	Mandatory Bans

The scheme shown does not reflect other drought mitigative measures that may be utilized in addition to the general conservation and restriction measures suggested here. The purpose of this scheme is primarily to establish basic priorities for water use within which to implement a water conservation or restriction program. Optional local responses dealing with water use management and water quality problems are discussed in the next chapter, "Dealing with Shortages and Water Quality Problems," by water management phase.